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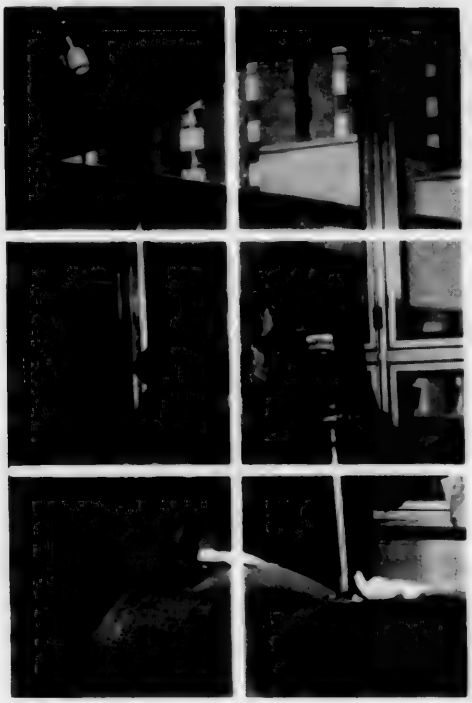

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the Journal of the

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Volume 37 Number 1
January 1969

Dedicated to the Science, Techniques and Applications Pertaining to the Photography of All Things Which Live or Which Have Lived

J. BIOL. PHOTOGR. ASS., VOL. 37, NO. 1, P. 1-72, JANUARY 1969

Cover Photograph

The cover photograph, by Guy Chantigny, University of Ottawa, shows a medical photographer at work in an operating room.

Not very often can the surgeon step aside to let the photographer take pictures at close range; many photographers have often needed to design elaborate stands to take photographs over the surgeon's shoulders with a telephoto lens.

The *Journal of the Biological Photographic Association*, published quarterly in January, April, July, and October, is the official publication of, and copyrighted © 1969 by, the Biological Photographic Association, Incorporated, an international society. Membership in the Association includes subscription to this journal.

Information for contributors is on the inside back cover of this issue.

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BIOLOGICAL PHOTOGRAPHIC ASSOCIATION, INCORPORATED
P.O. BOX 12866, PHILADELPHIA, PENNSYLVANIA, U.S.A. 19108

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Scientific exhibits: 31 May 1969

For further information write to:

Lardner A. Coffey, RBP, FBPA
General Chairman, 39th Annual Meeting
Section of Photography, Mayo Clinic
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THE BIOLOGICAL PHOTOGRAPHIC ASSOCIATION, INC.

The Association is an international professional organization of scientific photographers and other communications specialists who work in the natural and health sciences. Persons interested in scientific photography, but whose vocational status does not qualify them for active membership, may join the Association as affiliate members.

The B.P.A. was founded at Yale University, in 1931, by a group of scientific photographers, to provide a forum for the dissemination of information on methods, techniques, materials, and instrumentation as applied to scientific research and teaching. The B.P.A. has now over 20 chapters in the United States, Canada and India, with over 1000 members. There are also numerous members-at-large in many countries throughout the world.

Three classifications of membership are available: active, affiliate and sustaining. In recognition of professional excellence, award plaques and certificates are conferred annually for the best scientific paper published in this journal and presented at the annual meeting, and for outstanding contributions to still and motion pictures and TV tape exhibits. Fellowship in the B.P.A. is conferred for significant achievements and meritorious contributions to the advancement of photography in the biological sciences.

Annual meetings are held every autumn for the purpose of presentation of scientific programs of papers, workshops, scientific and commercial exhibits, and refresher courses. Regional and chapter meetings are also held.

The B.P.A. publishes this journal and the Newsletter, which informs members about chapter activities, personal information, and employment opportunities for scientific photographers.

The B.P.A. has established and maintains a Board of Registry for the purpose of examining and certifying qualified scientific photographers. The aim of this certification program is to raise standards and provide criteria for those interested in employing qualified scientific photographers. This program has been established in consultation with the United States and Canadian medical associations, hospital associations, dental associations, the American Institute of Biological Sciences, and several other influential professional societies.

Further information about the B.P.A. may be obtained from Mr. R. M. Christopher, Executive Secretary, P.O. Box 12866, Philadelphia, Pa., U.S.A. 18108.

Inquiries regarding the Certification Program are to be addressed to the Secretary of the Board of Registry, Mr. Will E. Renner, Medical Illustration Service, School of Medicine, University of California, Davis, Calif., U.S.A. 95616.

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Students in medicine, biology, or any of the other long-established sciences benefit from the work of their predecessors. They can get their professional training at most universities or colleges, their curricula are based on many years of teaching experience, and most academic libraries are well stocked with reference material.

The same is not the case with students in some of the sciences that have only recently evolved from various trades or from other scientific fields as the result of technological advances. Most institutions of higher learning are reluctant to establish courses in a new field of human endeavor. One of the reasons for this reluctance has to do with economy. A new faculty, school, or department requires considerable capital investment in buildings and equipment; qualified teachers are difficult to find and must be offered high salaries; and the initial registration consists usually of only a few students.

Scientific communications belong to the latter category. Lack of adequate training facilities has an adverse effect on attracting bright young men and women to enter the profession. Only those with a particularly high degree of interest and aptitude for photography, motion pictures, television, or any of the other branches of scientific communications dare to risk their future by entering a profession that is not yet fully established and universally recognized.

Many of those who are already professionally engaged in the field of scientific communications have entered this field from other professions by a stroke of providence; some were attracted to it by the challenge to pioneer a newly developing science. A new profession always offers many attractions and, often, better opportunities for advancement than the older professions that are already well established, have long histories of accomplishments, and, in some cases, attract more newcomers than can be employed.

The invention of the wheel several centuries ago must have been a tremendous impetus to the development of transportation methods. Today, there are no wheels used to orbit a spaceship around the world, or to carry it on a voyage to the moon. Scientific communications are today somewhere between the wheel and the spaceship era; there is so

much room for accomplishments and advancement that only a few other professions can offer similar opportunities, but the field is getting so complex that the scientific communicator must possess sound professional knowledge and a high degree of intellect to succeed in his endeavor.

The recent population explosion has increased the demand for services of medical doctors, agronomists and other scientists beyond our present capacity to increase training facilities for these specialists. To overcome physical limitations and train more students with available facilities and staff, educational and research institutions must make more effective use of modern communication methods. Photographic and art departments and audio-visual services have been maintained by most research and educational institutions for some years now; more recently, closed-circuit television services are being added. The demand for qualified scientific communicators increases in proportion to the increase of population and the demand for health services, food, shelter, and transportation.

This journal contributes to the advancement of scientific communication by offering an opportunity to share with other members of the profession knowledge and experiences gained through studies, research and practical work; it serves as a reference depository where those seeking solutions to their problems may look for answers; it is used by newcomers to our profession for learning about some of the intricacies of scientific communications that are not described in textbooks or other publications.

Scientific communicators have various educational backgrounds and a variety of experiences. The topics of papers contributed to this journal range from basic to highly complex and the manner in which they are presented reflects various degrees of writing experience. The editors of this journal are mindful of their obligations to disseminate information and to help both reader and author. Their obligation is to protect the former from misinformation, and to offer the latter the benefit of constructive criticism before the paper is published. It is no longer possible for one person to be an expert in all branches of scientific communication; to ascertain that the published material is not in error, and to help the editors obtain suitable material, the journal has engaged a number of experts to serve on the Editorial Board, or to assist as contributing editors or editorial consultants. Some of the new staff members are well known in the B.P.A., others are new to the Association.

Effective January 1, 1969, the Editorial Board assumed the responsibility for all policy matters. The Board, with the editor in chief as its chairman, consists of two more members: Mr. H. Lou Gibson and Lt. Col. Stephen P. Dittmann. Mr. Gibson and Lt. Col. Dittmann are well known in the B.P.A., they have served the Association in various capacities in the past, and their services will be a very valuable contribution to the *Journal* now. Mr. Gibson, a well-known author of numerous papers

on scientific photography, is with the Eastman Kodak Company, in Rochester, N.Y. Lt. Col. Dittmann, one of the top men in scientific communication on this continent, is Chief, Educational Television Division, U.S. Army Medical Services Corps, Fort Sam Houston, Texas.

The administration and production of the journal is the responsibility of the editor in chief and the managing editor.

Several contributing editors will help procure suitable material: Mr. Hans S. Dommasch, Chief, Photographic Services, University of Saskatchewan, Saskatoon, Sask., Canada (in Medicine); Mr. Alfred A. Blaker, Principal Photographer, Scientific Photographic Laboratory, University of California, Berkeley, Calif. (in the Natural Sciences); Mr. Clifford L. Freehe, Director, Health Sciences Television, School of Dentistry, University of Washington, Seattle, Wash. (in Dentistry); Mr. Donald H. Fritts, Associate Professor, College of Agriculture, Montana State University, Bozeman, Mont. (in Veterinary Medicine); Mr. Ervin W. Miller, Senior Photographer, Mayo Clinic, Rochester, Minn. (Technotes); Dr. Oscar W. Richards, Lecturer, College of Optometry, Pacific University, Forest Grove, Oregon (Book Reviews); and Mr. Ralph M. Glazier, Head, Illustration and Photographic Services, United States Department of Agriculture, Agricultural Research Service, Ames, Iowa (New Products). Mr. William L. M. Martinsen will continue to be the index editor.

Constructive criticism of submitted material often necessitates advice from more than one person. The editors have been very fortunate to engage a number of experts as editorial consultants: Dr. Helmut Haselmann, Professor and Director, Institute of Scientific Microscopy, University of Tübingen, Germany, and Mr. John V. Butterfield, Head, Photomicrography Section, Research and Development, Bausch & Lomb Company, Rochester, N.Y. (microscopy and photomicrography); Dr. J. Ross Colvin, Head, Biophysics, National Research Council of Canada, Ottawa (electron micrography); Dr. Peter Hansell, Director, Medical Photography and Illustration, Westminster Medical School, London, England, and Mr. Stanley J. McComb, Director, Section of Photography, Mayo Clinic, Rochester, Minn. (medical photography); Mr. Ross H. Jackson, Chief Photographer, Canada Department of Agriculture, Research Branch, bio-Graphic Unit, Ottawa (photography in the natural sciences); Mr. Warren Sturgis, President, Sturgis-Grant Productions, Inc., New York, N.Y., and Mr. John D. deBlois, producer of scientific motion pictures, National Research Council of Canada, Ottawa (motion pictures and television).

Any improvements in the makeup and layout that have been introduced in this issue are the contribution of Mrs. Mary Brett, Design Artist, Canada Department of Agriculture, Ottawa.

Stanley Klosevych

Workshop Courses in Scientific Photography

The Biological Photographic Association will offer courses in scientific photography preceding the 39th Annual Meeting, in Rochester, Minnesota, in August 1969. Tentatively scheduled for presentation this year are the following subjects:

Principles of Professional Scientific Photography
Patient Photography (Medical)
Small-object Photography (Photomacrography)
Photomicrography
Motion Pictures for Science
Closed-circuit Television
Management of Scientific Communication Establishments

These courses, established in 1965, are designed for practicing scientific photographers who wish to further their professional knowledge and thus provide more valuable services. It is in the interest of the employee and the employer to facilitate participation in these courses by staffs of scientific communication establishments. This year, newcomers to scientific photography, as well as established biophotographers interested in a refresher course, will, for the first time, have an opportunity to attend lectures and demonstrations in basic methods and simple instrumentation. For the experienced photographer, courses in advanced techniques will be offered; and for administrators of scientific communication departments, a special course in management is planned.

In the past, these courses were very popular, and it is expected that again this year for some of these courses the subscription limit will be reached within a few weeks after the official announcement. The final agenda will be announced in the next issue of this journal, and members will receive registration forms. B.P.A. membership is not obligatory for participation in these courses. Those who are not on the regular mailing list may obtain registration forms and pertinent information by writing to the course coordinator:

Percy W. Brooks, RBP, FBPA
Cornell University Medical College
1300 York Avenue, Room A-162
New York, N.Y., U.S.A. 10021

Journal of the Biological Photographic Association Vol. 37 No. 1 January 1969

How many words is a picture really worth?

ROBERT D. TSCHIRGI

I strongly suspect that the audience, while perhaps being charitable enough to not think me a charlatan, nevertheless may understandably wonder what are my credentials for addressing this group of professional biological photographers. Although I profess to know the rudimentary mechanics of picture taking, and I have even photographed a few biological objects in my time, I am sure that my portfolio would never pass muster among this illustrious group.

My reasons for appearing before you are, first and foremost, because I was invited to do so, and I sincerely consider it a privilege and an honor. As a professional biologist, I have been a longtime enthusiast and supporter of your talents. You are essential contributors to medicine, biomedical research and education, and I am pleased to have this opportunity to assure you of your vital role.

I also appear before you as a client and user of your products with, I believe, somewhat above average comprehension of the problems and complexities involved in their production.

And of course, I should mention that some of my very best friends are biological photographers and illustrators. Indeed, I would be quite pleased to have my daughter, if I had a daughter, marry one. It has been my observation among daughters that they tend to marry anyone they damn well please, anyway.

ABOUT THE AUTHOR

Robert D. Tschirgi, MD, PhD, is Vice-Chancellor, Academic Affairs, University of California, San Diego, California, U.S.A. 92037.

However, my comments today are not exclusively directed toward describing for you how well you are doing your job. That is self evident, and an accomplishment in which you can take well-deserved pride. Rather, I wish to suggest that there is a need for better and more effective use of your technically excellent products, and that perhaps you as a profession should assume a greater responsibility for educating and advising your clients in the best ways to use the photographs, films, and illustrations which you create for them.

Your profession is relatively young. The technology for producing a two-dimensional image of the environment on a chemically sensitized surface is less than one hundred and fifty years old. The technology required to make these images appear to move is less than one hundred years old. The technology for distributing moving images almost instantaneously over great distances is less than fifty years old.

We have come to use these remarkably sophisticated technologies for two primary purposes: for aesthetic gratification as an art form, and as a means of communicating information. One can argue that these categories are not mutually exclusive, and they most certainly are not, and also that even the primarily

aesthetic function of photography is, when rigorously analyzed, a process of communicating information. Nevertheless, I believe it is useful to recognize that the intent of the photographer usually can be assigned either more toward the production of an aesthetic experience in the viewer or conversely toward the communication of information irrespective of its aesthetic significance.

This spectrum of purpose has its parallel in literature from the instruction manual at the purely utilitarian end of the scale to belles lettres and the use of words solely for their euphony at the other. Poetry is, after all, an attempt to provide an aesthetic experience which transcends the mere literal definitions of the words used, and such writers as Vachel Lindsay, Edith Sitweil, and James Joyce have exploited an aesthetic effect of words in which meaning is subordinated to the musical quality of the sounds themselves. The parallel use of photography to create abstract and nonrepresentational works of art is well known to you all.

The difference between these two functions, the utilitarian and the aesthetic, is a matter of priority and degree. When the purpose is to communicate information, the photograph or the paragraph should be as aesthetically pleasing as possible, but not at the expense of clarity and informational content. Both of these uses of the photographic process can be equally creative and rewarding to the photographer, and each demands the greatest technical skill combined with a full knowledge of the proper use of the medium to achieve the desired goal.

Now what does all this have to do with biological photographers? In general, the biological photographer is concerned in his profession primarily with the communication of information, and only secondarily with the aesthetic impact of his product. To be sure, the more attractive the package in which the information is wrapped, the more likely it is to be swallowed, but the talents of the biological photographer are seldom called upon for the primary purpose of luring the unwary reader with provocative pictures, or providing an emotional attraction for an irrational point of view. He is basically concerned with lucid exposition rather than propaganda or art.

To accomplish this function most effectively, the biological photographer should have competence in three areas. He must have technical mastery of all necessary photographic mechanisms and processes; he must have a general knowledge of the scientific fields to which he will be applying photography; and he must have a thorough understanding of those aspects of communication theory which concern the use of verbal and pictorial symbols in the transfer of information.

Generally speaking, the biological photographers with whom I have associated are remarkably competent in the technical requirements of their profession. Their skills include not only the conventional photographic processes, but the special knowledge of microscopic optics, photomacrography, infrared photography and many other unique techniques involved in medical and biological uses of photography. Furthermore, they usually have a surprisingly good working knowledge of the scientific field to which they are applying their skills and have always been willing and enthusiastic to learn more. Because of this, they could frequently suggest and develop better techniques or approaches to illustrate the subject.

It is with respect to the last category, the principles of communication theory applicable to the use of pictorial materials, where both the photographer and the scientist or physician are most in need of education. It is in this area that I believe the professional biological photographer should most especially expand his competence so that he can advise the author when and where to use illustrative material, what sort of illustrations would be most suitable, and how illustrations should be integrated with textual material to be most effective. Thus I am proposing that biological illustrators and photographers should become at least as concerned and informed about the use of their products as they are about the technology of manufacturing them.

Most of my audience will agree that this area has so far received relatively little emphasis in the conventional training of biological photographers, nor is it even recognized among scientists and physicians as a service which illustrators and photographers might perform. You will notice that I am combining illustrators and photographers in these comments because both deal with essentially the same problems from the standpoint of principles of communication. Both are concerned primarily with two-dimensional graphic representations of portions of the environment as a means of conveying information to an uninformed audience.

Which brings us to the question posed in the title of this address, "How many words is a picture really worth?" The Confucian estimate of one thousand is clearly an oversimplification, and the answer must necessarily depend on what information the picture is supposed to convey. In a treatise on insulin production by the islands of Langerhans a picture of the islands of Hawaii is worth no words whatsoever. On the other hand, in an article on birth control a picture of an Indian mother holding her dead baby bloated from starvation is worth an incalculable number of words since no verbal description can convey the emotional impact of the photograph.

Thus, pictures and words are not entirely equatable, and each has a province where the other is a poor second. When the purpose of words is to elicit an objective visual image in the mind of the reader, such as an anatomical description, then a picture is generally a more efficient and effective means of conveying the information. When words and mathematical symbols are used to express an abstract concept such as irrational numbers, any attempt at pictorial representation may be seriously misleading.

The relative usefulness of words and pictures is not a simple fixed relationship which once determined may then be applied with mathematical precision to all circumstances. Among the important factors influencing the number of words a picture is worth is the nature of the audience. An extreme example would be an audience illiterate in the language of the textual material. In this circumstance, the entire message must be conveyed by pictures alone. Similarly, the educational background and previous visual experiences of the audience must be taken into account. To an unsophisticated audience unfamiliar with the phenomenon of optical magnification, photomicrographs would represent only meaningless patterns.

I have chosen extreme and unlikely examples to illustrate the point, but I am sure you can recognize the applicability of the principle to more usual situ-

ations such as the need for relatively simplified diagrams and illustrations in introductory textbooks.

Another audience factor which must be evaluated is the amount of time which the viewer will have to examine the illustration. Again, the extreme situation would be a tachistoscopic presentation where the image is shown for only a fraction of a second. Simple silhouettes and general forms are all that can be recognized, although previous experience can greatly increase the viewer's ability to obtain information from such brief exposures. You may have noticed the use of rapid scene changes, often less than a second, in avant-garde movies and now increasingly in television commercials. The effectiveness of this technique depends on the complete familiarity with the visual clichés used in the television and motion picture media which the viewing public has gained. We need see only a glimpse of a sun-tanned, bikini-clad figure and a splashing surf to know that Coca Cola makes any beach party ever so much more fun.

At the other end of the spectrum, the reader of a technical treatise will presumably be willing to study an illustration for as long as necessary to extract its total message. Slides are, of course, an important instance where the viewer is given a fixed period for inspection of the illustration and he must be able to obtain the desired information in that time. I am sure I do not need to describe for you the sins of commission and omission which are commonplace in many of the slides shown at scientific meetings. Here is an important area where the scientist and physician are much in need of counsel and advice.

Another variable which determines the worth of a picture is the quality of its reproduction. Obviously an illustration in which a significant portion of the information is dependent on color loses its effectiveness in black and white and for some situations where very slight differences in color values are important, as in dermatological lesions for example, even the best color reproduction currently available may be inadequate. Robert Benchley once described the illustrations in Paris newspapers as looking as if they had been etched on slices of mouldy bread. If such is to be the manner of public presentation, then the prudent photographer creates illustrations in which all important information is displayed without recourse to any gradations in contrast between black and white nor details beyond broad lines and bold outlines. Although few biologists and physicians are concerned with publishing their works primarily in Paris newspapers, let me point out that the ubiquitous Xerox machine has become a primary source for reference copies of scientific literature, and you are all aware of the unrecognizable mess which the Xerox process produces from half-tone originals.

In some cases an illustration should be omitted because it is redundant, yet in other instances an illustration should be included because it is redundant. When the intent of the document is to inform, as concisely and economically as possible, a sophisticated highly motivated audience, well versed in the background of the subject, then redundancy should be minimized. What is adequately stated in words need not be illustrated, and what is better illustrated need not be described in repetitious detail. On the other hand, when the intent is to instruct a naive audience and especially to provide a framework of hierarchy — that is, to distinguish between the more im-

portant and the less important items under discussion — then the more important elements can be emphasized in a memorable way by stating them in both words and pictures.

I have mentioned only a few of the more obvious principles of communication which are important to the proper use of your carefully created products. A key-note address cannot — and should not — attempt to provide a short course in communication theory, but should rather point toward a direction for further growth and development of your profession. Thus, I am suggesting that you expand your professional concern beyond the creation of your product to the most effective use of that product. There is a rapidly growing body of knowledge in this area of communication theory and a great deal of interest in it has been generated. But as yet there is no communications expert in the biomedical team who can advise and counsel the scientific author and lecturer. You are in the best position to assume that responsibility. It is the logical extension of your services and a logical complement to your technical skills.

Keynote address, delivered at the 38th Annual Meeting, Biological Photographic Association, Inc., Los Angeles, California, 12-15 August 1968.

meetings calendar

39th Annual Meeting
Biological Photographic Association, Inc.
August 18 - 21, 1969
Kahler Hotel
Rochester, Minnesota
(see details on page 2)

40th Annual Meeting
Biological Photographic Association, Inc.
held jointly with the
Association of Medical Illustrators
August 10 - 13, 1970
Houston, Texas

For further information write to:
LYNN BALDWIN, RBP, FBPA
General Chairman, 40th Annual Meeting
Department of Medical Communications
M.D. Anderson Hospital
Texas Medical Center
Houston, Texas 77025, U.S.A.

41st Annual Meeting
Biological Photographic Association, Inc.
International Congress on Scientific Communications
August 23 - 27, 1971
Chateau Laurier Hotel
Ottawa, Ontario, Canada

For further information write to:
JOHN D. DEBLOIS, RBP
General Chairman, 41st Annual Meeting
National Research Council of Canada
Montreal Road Laboratories
Building M23A
Ottawa, Ontario, Canada

Journal of the Biological Photographic Association Vol. 37 No. 1 January 1969

Development of broad audio-visual services with limited facilities

LEON J. LeBEAU

While serving as Visiting Professor of Microbiology at the new medical school of Chiengmai, the second largest city of Thailand, I became aware of the pressing need for audio-visual support for the educational program. This need was far more evident abroad than at home because of the ready availability of teaching slides and motion pictures in the United States.

Such slides, however, in addition to being not readily available, have limited value in Southeast Asia. For instance, statistics on incidence of infectious disease in the United States hardly represent pertinent data for the Thai student, and pictures of white-skinned, blond-haired patients poorly prepare the medical student to recognize skin conditions in the brown-skinned patients he will examine. It was also evident that lack of trained personnel, limited funds, and irregular availability of teaching cases indicated the need of developing a locally prepared slide collection of teaching materials.

An analysis of the audio-visual requirements showed a need for:

- Copy work of public health data and local statistics as well as current data from journals and monographs
- Color slides of laboratory demonstrations that are difficult to reproduce, of equipment in short supply, and of cultures and reactions that are difficult to maintain
- Patient and specimen records
- Photomicrographs of significant organisms, tissue cultures, and colonies of microorganisms
- Community health exhibits and public relations displays to illustrate health problems and their solutions.

Other decisions for audio-visual service had to be made with consideration of limited space and budget at the new school. Nikon cameras, lenses, and accessories were selected for their availability and lower cost in that part of the world, as well as for the quality and versatility that Nikon provides. To facilitate the photographic service, three cabinets were designed and fabricated by local craftsmen. Plans were based upon need and guided by analysis of functional use. Ideas were provided by reported devices and equipment (Albright, 1959; Beiter and Bohrod, 1944; Kodak Publication S-21, 1965, N-5, 1966, M-1, 1968, S-8, 1968; Lewis and Hopper, 1961; Schmidt, 1933, 1934; Schutz, 1958; Taylor, 1957; Vetter, 1960; Wither, 1958). Figure 1 shows the basic photographic cabinet and Figure 2 provides diagrams of the unit.

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The top center drawing shows the rear of the cabinet. The uppermost portion is used to store the legs and posts. The middle section is a transillumination drawer. The top of the cabinet is hinged to allow it to tilt up and form a drawing board (Figure 3). Sliding panels on the right side and left front serve as trays to hold illustration materials, which are stored in the center drawer when not needed. Doors under the drawer open from the back to provide knee room.

With the drawing board down and the leveling copy board in position, as shown in Figure 4, the unit is ready for copy work. Two colortrans minilites provide the illumination. The lighting control box has a three-way switch to give series wiring for focusing and parallel wiring for full illumination as well as "off" position. The light stands adjust to copy-lamp distances ranging from 18 inches to 5 feet.

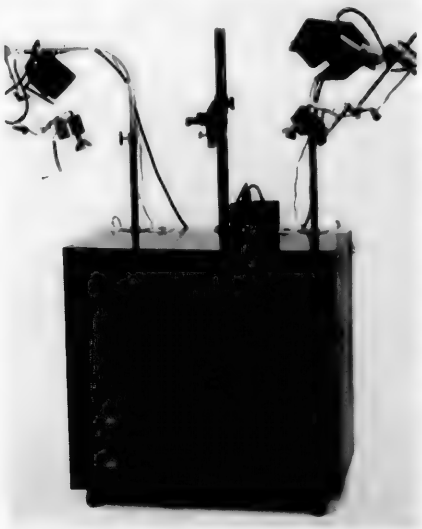

Figure 1. Basic photographic cabinet.

In Figure 5 the drawer is extended and the leveling legs (not shown) and posts are in place. Six 75-watt tungsten lamps are the source for transillumination and two 150-watt reflector bulbs give oblique illumination. A small fan in the right-rear corner keeps the unit cool. Plate glass is shown inserted in the slots of the aluminum posts. For photography of the unstained bands the opal glass is removed and the oblique lighting is used with a black cardboard over tungsten bulbs to give the dark-ground illumination. The versatility and simplicity of the system are emphasized by elaborate illumination techniques for visualizing precipitin bands mentioned in current literature (Bowden and Horn, 1962; Glazier, 1966; Jackson, 1959; Klontz, Ridgeway, and Wilson, 1960; Murchio, 1960; Noce and Alley, 1961). This same figure and Figure 6 illustrate the placement of the glass. The white dimmer switches can be seen at the rear on top of the cabinet. The one on the left controls the tungsten lamps and the one on the right regulates the intensity of the oblique lighting. In Figure 6, the rack and pinion bracket for the electronic flash units can be seen. Depth of field is maintained by holding the opening at $f/22$ or $f/16$ while controlling exposure by raising or lowering the flash units. The transillumination box is useful in recording precipitate bands in agar. Figure 6 also shows that the setup can be used for transillumination of stained precipitin bands. Plastic sheets of a color complementary to the stain are used to emphasize contrast.

The posts are reversible so that the vertical slots on the opposite side allow the glass to be held in the vertical position as shown in Figure 7. Vertical positioning of the plate glass is used mainly

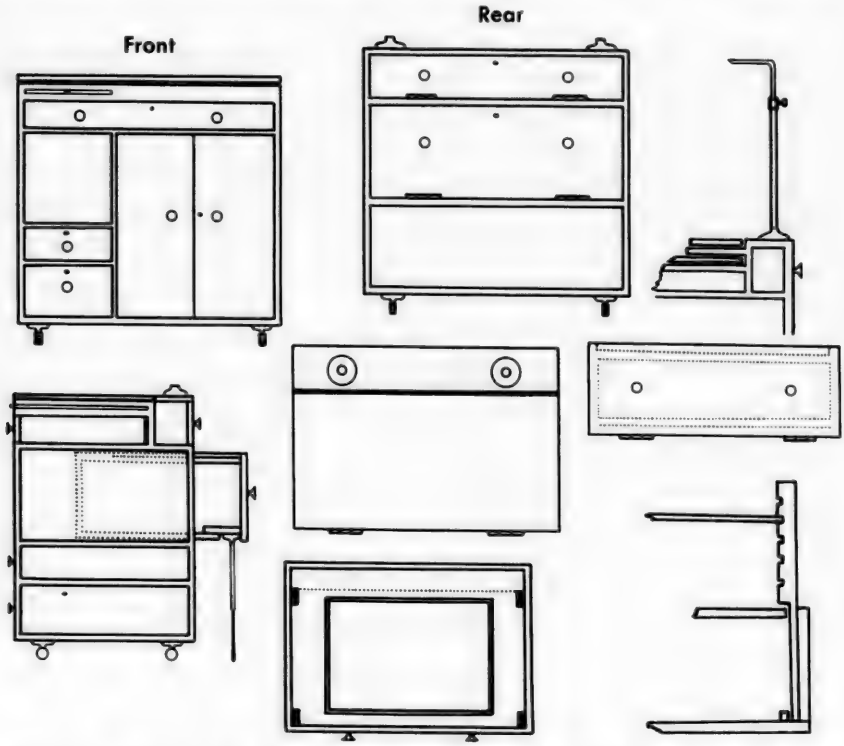

Figure 2. Design for basic photographic cabinet. Center drawings show cabinet from top and the drawer from above. At the lower right corner is seen a slotted post fitted into the drawer slots.

Figure 3. Basic cabinet with tilted top to serve as a drawing board.

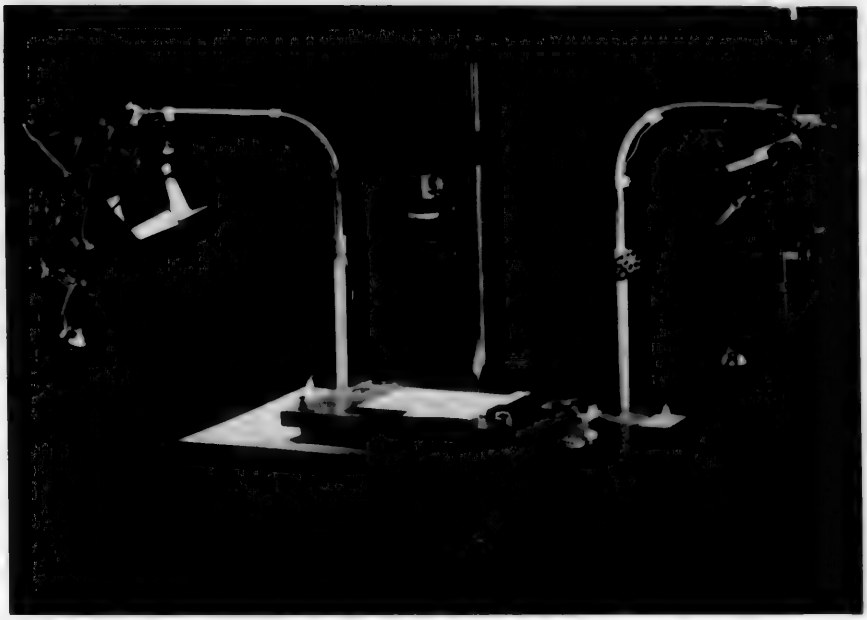

Figure 4. Copy board with leveling feet on top of basic cabinet.

for liquid culture media. To avoid use of unsightly test tube racks, double-face masking tape is used to fasten tubes to glass. Storage of background boards of various colors as well as colored construction paper and acetate sheets is facilitated by the unit shown in Figure 7. It should be noted that the cabinet, 36

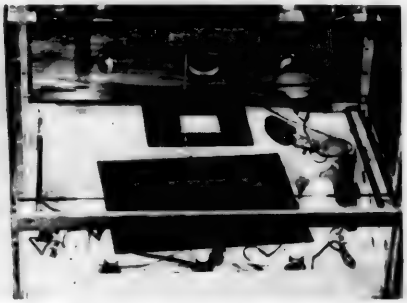

Figure 5. Oblique lighting for visualization of unstained precipitin bands in agar.

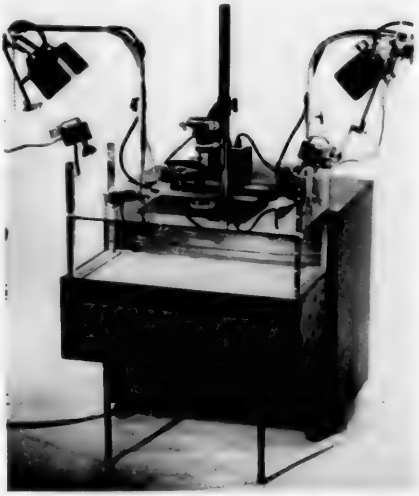

Figure 6. Transillumination with balanced overhead lighting for bacterial cultures.

inches wide by 36 inches high by 30 inches from front to rear, offers ample storage space for cameras and accessories in the top drawers. Slide storage is also shown below.

A third cabinet is shown in Figures 8 and 9. One side of the cabinet is designed to provide a microscope table of comfortable height. Figure 10 illustrates the table with its built-in voltage meter. It also shows a Zeiss SMX dissecting microscope with a monocular head and a transilluminator light for bacterial colony close-ups. For higher magnifications the same table is used with a Zeiss standard trinocular microscope.

The reverse side of the cabinet houses the slide-duplicating unit. Figure 11 shows the use of a photoflood bulb as a light source, but the unit can be used with electronic flash or Tensor lamp as well. Above the control panel can be seen the filter drawer, which holds the color printing filters, the heat filter, and the opal glass. The masking plates on top accept 3¼x4-inch or 2x2-inch slides. Slides can be copied by projection off a right angle mirror onto a ground glass, as shown in Figure 12. This method is used for duplicating slides with overlay wording or diagrams.

The left side of this cabinet contains a three-mirror rear-view projection unit (Kodak Publication T-47, 1962), as shown in Figures 13 and 14 and, by diagram, in Figures 8 and 9. This unit was very valuable for previewing slides in a room which could not be darkened in daylight hours. It was often used for teaching of small groups in the office.

For clinical photography the medical Nikkor lens was used as well as the 105-

Figure 7. Storage unit for equipment, background boards, and colored acetate sheets.

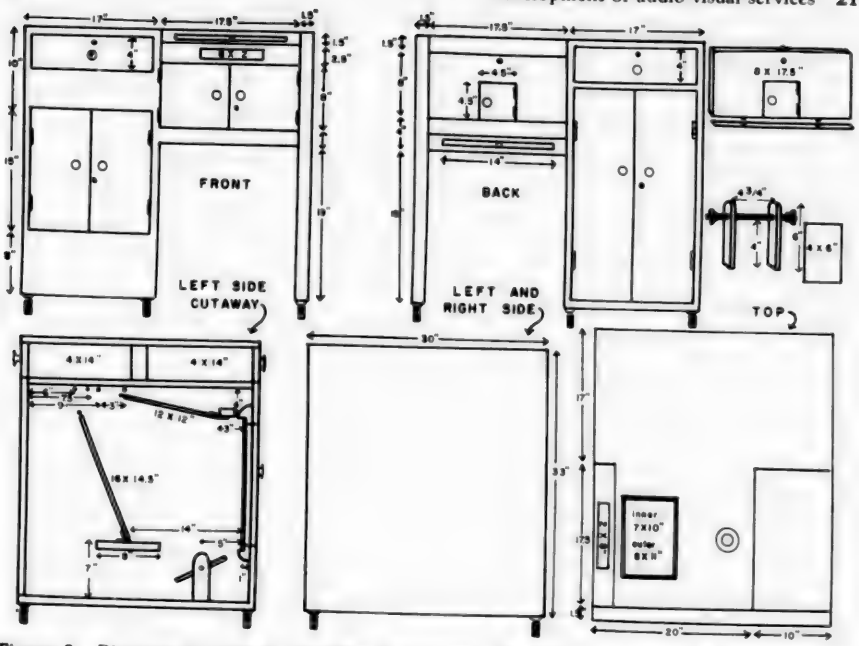

Figure 8. Diagram of cabinet for slide duplicating, photomicrography, and slide projection.

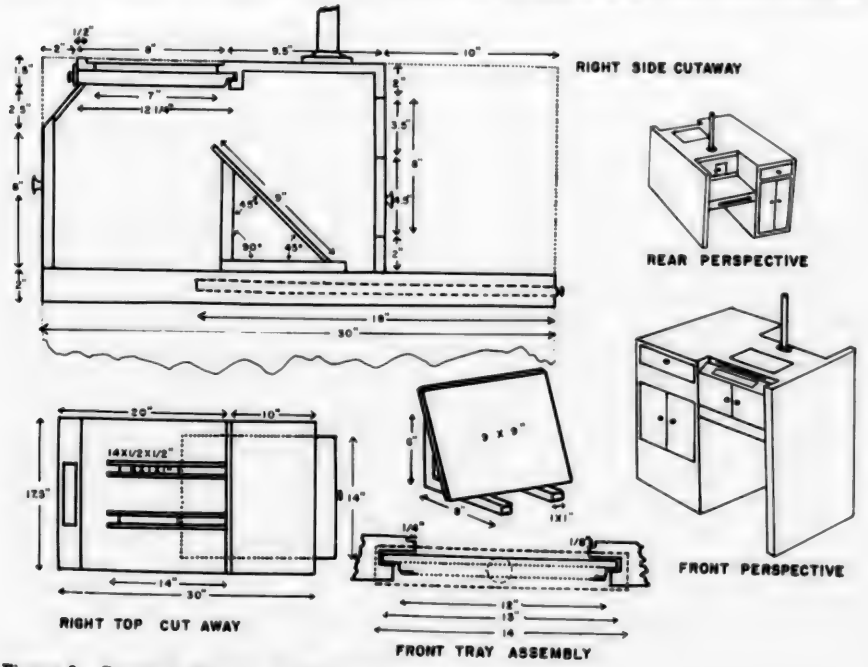

Figure 9. Detailed diagram of slide duplicating cabinet.

Figure 10. Table has a built-in power supply and volt meter. Height of table, 23 inches, assures convenient focusing.

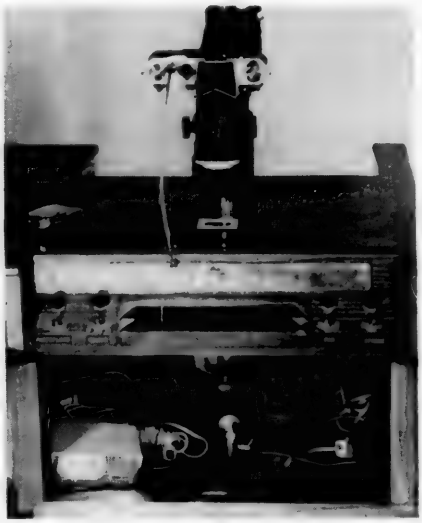

Figure 11. Slide copy box with photoflood bulb in position. Electronic flash unit can replace photoflood lamp. Filter drawer is above lighting control panel. Vents in the panel allow air to be drawn over the lamp by the exhaust fan in the back of the box.

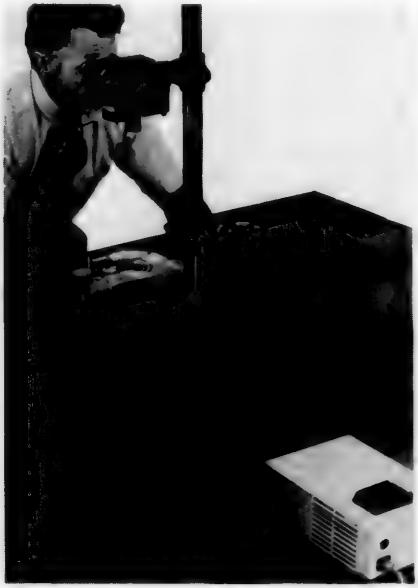

Figure 12. Slide copy by projection on a ground-glass screen is used when overlay diagrams and lettering are needed.

Figure 13. Rear view of three-mirror rear-projection cabinet.

Figure 14. Front view of three-mirror projection cabinet used for previewing slides and small-group teaching in a lighted office.

mm auto Nikkor and three electronic flash units with slaves. When required, backdrops of black, white or pale-blue velvet 54 inches wide and 7 feet long were unrolled from their wooden dowels.

Use of this equipment during 3 years resulted in production of over 3,000 teaching slides and the preparation of three exhibits. Three similar units to be used in other interested departments were also built.

Summary

In an effort to establish medical photographic services in a medical school in Northern Thailand, the 35-mm system was chosen because of limited space and budget at the school. Nikon camera lenses and accessories were selected for their availability and low cost in that part of the world as well as for their quality and versatility. Compact cabinets were designed and fabricated to assist in providing quality illustration, copy, transillumination, slide reproduction and photomicrographic facilities.

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Enlarger modification to produce electron micrographic prints of highest definition

BURTON C. STAUGAARD

Electron microscopists are striving to see the finest possible detail in their photographs. To help achieve this end, manufacturers of electron microscopes are constantly working to increase the resolving power of their instruments, and suppliers of electron-sensitive plates and film and associated processing solutions are likewise working to improve the resolving power and acutance of their products. One important link in the chain from tissue fixation to final photographic print has, in my opinion, not received the emphasis it deserves. Several writers on the subject of electron microscope techniques have mentioned equipment to make enlarged prints from the electron microscope film or plate negative, without calling sufficient attention to the importance of the type of light source in the enlarger.

Pease (1964) states that "a 'condenser type' enlarger produces an image with superior contrast," but does not mention any specific source of light or lamp type. Kabe (1965) mentions connection of a "6 volt point light source," but then adds: "The enlarger is always equipped with a 220 volt light source," thereby leaving some confusion in my mind about the actual light source used or recommended. Sjostrand (1967) states: "The enlarger is equipped with either an ordinary 220-volt enlarging light bulb or a small-sized low-voltage (6 volts) bulb forming a point light source." Neither Kabe nor Sjostrand mention the desirability of a condenser-type enlarger.

Portrait photographers have long known that enlargements made with a "diffusion" type of enlarger give "softer" images by virtue of the loss of fine details such as age wrinkles and skin blemishes, and thus produce more flattering portraits. Most scientific photographers insist on a "condenser" type of enlarger because it gives sharper prints with finer detail. Both types of enlargers, however, are commonly equipped with a white or opal glass bulb, an example of which is the No. 212 enlarger lamp. This lamp converts a condenser enlarger partway back to a diffusion enlarger, because the white glass envelope of the bulb, the apparent source of light, is so large and diffuse. In practice as well as theory, a white lamp is not capable of producing the maximum amount of sharpness in a print. You simply cannot transfer all of the detailed information from the negative to the print with a diffuse source of light in the enlarger.

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The difference in obtainable definition in the enlarged print depends on the physical size of the source of light and the means employed (lenses or diffusion screens) to utilize the light for illumination of the negative. The principles underlying the above statement are well known to everyone familiar with the importance of the illumination system used with the compound microscope. However, even as many microscopes are sold today with ground-glass diffusion discs and frosted lamps, so also are many photographic enlargers still used with a white, frosted, or opal lamp, in contradiction to the recognized advantages of a source of light approaching a "point-source" in size. Peter Gray (1964) leaves no doubt in this statement: "It is impossible to get the best service from a first-class microscope with a second-class illuminator. The minimum requirements . . . are . . . a high intensity lamp with a compact filament." If an opal lamp or ground-glass disc is unsatisfactory for a microscope illuminator, the same optical principles dictate the unsuitability of this type of light source for an enlarger.

The reasons for the superior light source not being utilized sooner in this laboratory were the cost involved in replacing the enlarger and the lack of a light-source-only replacement. The Durst S45-EM enlarger (Ehrenreich Photo-Optical Industries Inc., Garden City, N.Y.) is available with a "point-light source," and a "point-light source" accessory is available for the Omega D-2 and D-3 enlargers (ULE, 21 Spencer Street, Stoneham, Mass.).

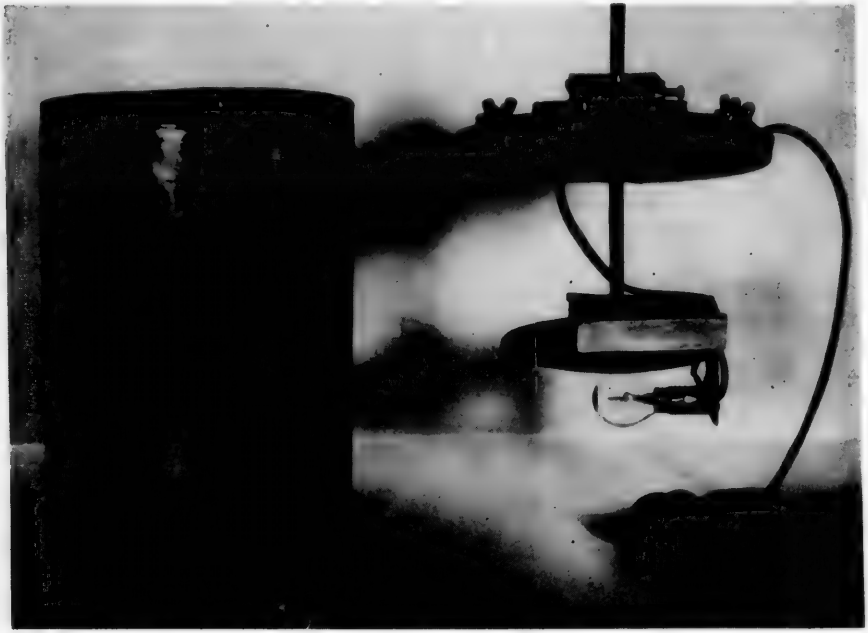

Figure 1. Lamp housing on left, and plywood disc with centerable lamp carrier (before being painted) on right. Lamp is G.E. Type BMY, 120-volt, 100-watt.

In this laboratory we have been using a Beseler Model 45 MCRX condenser enlarger with a Wollensack 135 mm f/4.5 Enlarging Raptar lens and a No. 212 (white) enlarging lamp. We decided to determine if we could improve the quality of our enlargements by converting the lamp housing of our enlarger to accommodate a lamp having a clear envelope and a small filament in place of the white-bulb type of lamp.

Enlarger Modification

A new lamp housing (Figure 1) was made from a 10-inch-long section of 7-inch-diameter galvanized sheet metal duct, which just fits the Beseler enlarger, in place of the regular lamp housing. A disc of plywood at the upper end of the duct supports a 3/8-inch-diameter rod and provides for horizontal movement of the lamp in two directions, so that accurate centering — of crucial importance — can be accomplished. The rod carrying the lamp socket is adjustable up and down along the optical axis of the enlarger to permit proper positioning of the lamp in relation to the condenser lenses.

The lamp used was a single-contact, bayonet-base, 120-volt, 100-watt, G.E. Type BMY. The wire from the lamp socket was plugged into the "Resistrol" voltage regulator of the enlarger, which was connected to the outlet of a Time-O-Lite timer. A shield above the lamp prevents the wires from coming into contact with the hot lamp, and the entire inside of the housing is coated with non-reflective black paint to reduce stray light.

Operation

With the new lamp housing substituted for the original one, a negative is placed in the carrier, height adjustment of the enlarger is made for proper magnification, and close to approximate focus of the negative image on the enlarging easel is established with the lens diaphragm wide open.

The negative carrier is removed and the lens diaphragm stopped down to f/8 or f/11. The lamp is moved up or down until the image of the filament appears as a bright disc against a dark background. This disc is centered with the horizontal adjustments of the lamp carrier. The lens diaphragm is opened fully. If any blue fringing or ringing is seen on the easel, the lamp is moved up or down until the color disappears. A slight reddish fringe at the extreme edge is acceptable.

The negative is now replaced and its image is carefully focused with a magnifying focusing aid. The lens is left open at its maximum aperture of f/4.5 or f/5.6. Control of exposure is made by adjustment of the lamp voltage and by length of exposure time. Changes in magnification of successive prints will probably require slight adjustment of the lamp-to-condenser distance but will probably not require centering correction. The 100-watt clear lamp in a condenser enlarger is far more efficient than a white lamp, and a fractional-second timer (Lektra, Model TM-560) is desirable.

After using the modified enlarger for a while, we decided that the very short exposure times were a disadvantage, and that the use of neutral-density filters to reduce the light intensity would be a nuisance as well as a possible source of degradation of the image. Accordingly, a further modification was undertaken to allow use of a clear lamp of a lower wattage in place of the 100-watt lamp.

Power Supply

After trying numerous lamps of various wattages, voltages, and filament sizes, we decided on a No. 1154 lamp, which

operates at 6.3 volts and is unique in that it has two filaments. The large filament uses about 16 watts of power and the small filament about 4½ watts. This lamp eliminates one of the chief disadvantages of the so-called "point-light source" illuminators, which is the change of the spectral quality of the illumination towards a predominantly yellow color as the voltage is reduced in an attempt to achieve an exposure time long enough so that dodging can be accomplished. (It is very difficult to dodge with an exposure of 0.8 seconds!) If the voltage

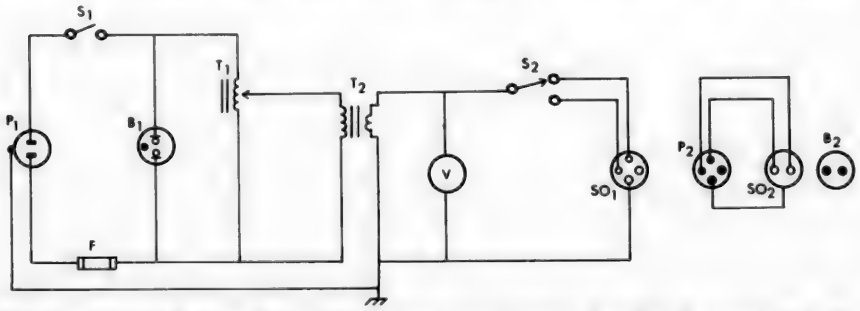

Figure 2. Circuit diagram of low voltage lamp power supply. Parts list: B_1, neon pilot light; B_2, No. 1154 bulb (double filament); F, fuse, 1 amp.; P_1, plug, with ground pin; P_2, plug, 4 conductor; S_1, switch, SPST (power "On-Off"); S_2, switch, SPDT, center off ("Filament Selector"); SO_1, socket, 4 conductor; SO_2, socket, double contact, medium bayonet, indexing; T_1, transformer, variable (Powerstat 10-B); T_2, transformer, 117 v. primary, 6.3 v. 3 a. secondary; V, voltmeter, 0-10 or 0-15 volts AC.

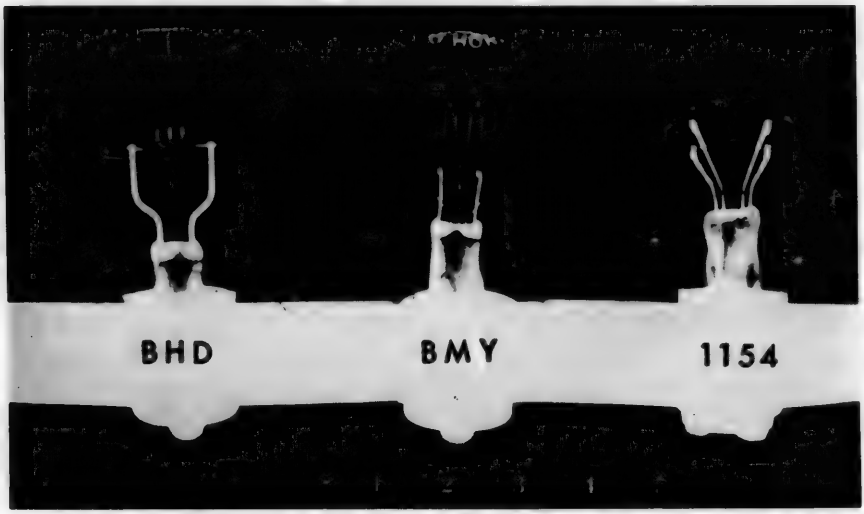

Figure 3. Comparison of filament sizes of three types of lamps used in enlargers. BHD (20-volt) is the type supplied by Durst with their "Varipoint" point-light source. BMY (120-volt) was used in initial trials with the Beseler enlarger. No. 1154 (6.3-volt, 2.63- and 0.75-amp.) is the dual-filament lamp. Note the relatively small size of the filaments.

is too low, the light is yellow like the safelight, and the photographic paper doesn't record the image, because it is only sensitive to blue. The dual-filament lamp allows the selection of the smaller filament with about one-fourth of the light output, but at a normal voltage, and hence with the proper spectral emission. Since the lens must always be used "wide open," the usual control of light intensity over a wide range by closing down the aperture of the lens is not possible, and selection of a lower-wattage filament is far more convenient

Figure 4. Low-voltage power supply with voltmeter, adjustable voltage control and filament selector switch ("Lamp Brightness, Lo and Hi"). Lamp carrier is slightly different from that in Figure 1. Note provision for lateral lamp carrier motion on top of lamp housing.

Figure 5. Overall view of Beseler enlarger with new lamp housing, low-voltage power supply, and timer.

than juggling neutral-density filters or replacing lamps.

A suitable power supply was constructed. The circuit diagram (Figure 2) shows a simple arrangement of a variable transformer (T_1), a 110/6.3-volt step-down transformer (T_2), a voltmeter and appropriate switches, fuse, and pilot light to complete the circuit. A double-contact bayonet-base socket replaced the single-contact socket used previously, and a three-conductor cable was utilized to connect the power supply and the lamp housing. The voltmeter is not necessary, but it allows accurate reproduction of lamp intensity when additional prints are made at a later time and if a record of exposure time and voltage was made initially.

Results

After first tests showed that prints markedly sharper and with more contrast were obtained with the small-filament clear lamp, we wondered whether a further improvement could be obtained by using a more highly corrected lens. Accordingly, an electron micrographic plate was printed with combinations of six different light sources, lenses, and *f*-stops at a magnification of 4.2 times onto Kodabromide F-2 paper (Figure 6). Focusing on the silver grains of the negative was done with great care, with the use of a magnifying focusing aid.

Additional magnification to clearly demonstrate the results was obtained by taking low-power photomicrographs ($\times 9$) of a small portion of each of the six 8×10-inch prints (Figures 7, 8, 9, 10, 11, 12). The first print (Figure 7) was made with the No. 1154 lamp (16-watt filament) and a 105-mm Schneider Componon lens at $f/5.6$. Additional prints were made in the following way: 8 with the No. 1154 lamp, 135-mm Wollensack Raptar lens at $f/4.5$; 9 with the No. 212 lamp, Componon lens at $f/11$; 10 with the No. 212 lamp, Componon lens at $f/5.6$; 11 with the No. 212 lamp, Raptar lens at $f/8$; 12 with the No. 212 lamp, Raptar lens at $f/4.5$.

After processing, washing and drying, the six prints were examined and arranged sequentially in order of decreasing sharpness, without reference to the identification on their backs. Three different electron microscopists arranged them in the same order: 7, 8, 9, 10, 11, 12.

All agreed that 7 was clearly the sharpest print (No. 1154 lamp, Componon lens at $f/5.6$) and that 8 was close but definitely not as good (No. 1154 lamp, Raptar lens at $f/4.5$). The next four were progressively worse. Under all conditions the Componon lens gave superior results. With the No. 212 lamp, both lenses gave better results when stopped down to $f/8$ or $f/11$. It is unmistakably clear, however, that the results obtainable with a diffuse-light source (No. 212 lamp) under the best conditions (Componon lens at $f/11$) cannot compare with the superior results obtained with the compact-filament clear glass lamp. Exposure time with the No. 1154 16-watt lamp was 8 seconds at $f/5.6$ and with the No. 212 150-watt lamp 4½ seconds at $f/5.6$ and 20 seconds at $f/11$.

In an additional test, a high-contrast negative of black india ink lines on a white background was used. This negative was projection printed onto positive film with a 75-mm $f/4.5$ Kodak Ektar lens and combinations of three different light sources and f stops at a magnification of about four times. These positives were then further enlarged by nine times onto paper for ease of examination with the unaided eye. Figure 13 was printed with the No. 1154 lamp (4½-watt filament) and the Ektar lens at $f/4.5$. Figure 14 was printed with the No. 212 lamp and the Ektar lens at $f/8$. Figure 15 was printed with the No. 212 lamp and

Figure 6. Electron micrograph of rat cardiac muscle (by Jole Bernett), about ×10,000. Kodak High Resolution Plate, 3¼ × 4 inches, enlarged 4.2 times.

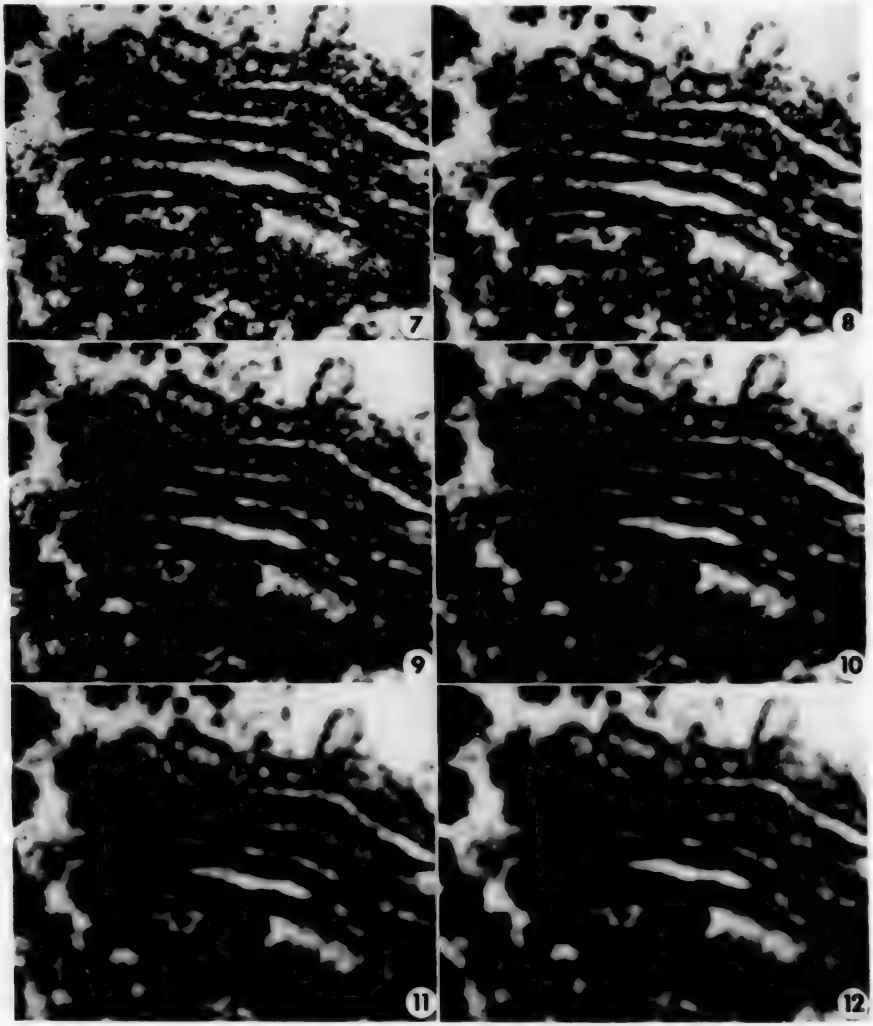

Figure 7. Low-power photomicrograph (×9) of detail from the upper right portion of an 8 × 10-inch print, which was enlarged with a No. 1154 lamp and a Componon lens at *f*/5.6; Figure 8. Same, with No. 1154 lamp and Raptar lens at *f*/4.5; Figure 9. Same, with No. 212 lamp and Componon lens at *f*/11; Figure 10. Same, with No. 212 lamp and Componon lens at *f*/5.6; Figure 11. Same, with No. 212 lamp and Raptar lens at *f*/8; Figure 12. Same, with No. 212 lamp and Raptar lens at *f*/4.5.

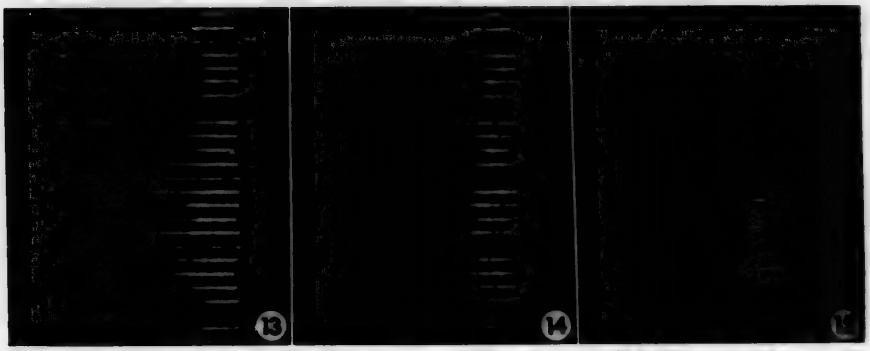

Figure 13. Enlargement with No. 1154 lamp and Ektar lens at f/4.5; Figure 14. Same, with No. 212 lamp and Ektar lens at f/8; Figure 15. Same, with No. 212 lamp and Ektar lens at f/4.5.

the Ektar lens at $f/4.5$. The contrast and sharpness of Figure 13 is clearly superior to Figure 14, and 15 is the poorest.

The above results show unequivocally that the same negative produced a sharper print when a clear lamp with a small filament was used instead of the white No. 212 enlarger lamp. Use of the lower-wattage lamp allowed a convenient exposure time, produced less heat in the lamp housing, and more closely approached the "point-source" size of the ideal photon emitter. We are now confident that we are able to transfer to the print all of the detail that we recorded on the negative when making the exposure in the electron microscope.

Conclusions

Marked improvements in the quality of electron micrograph enlargements, particularly in the visualization of fine detail, can be obtained by replacing the ordinary white or opal enlarging lamp of a condenser enlarger with a small-filament clear lamp. Hall (1958) correctly refers to this type of lamp as a "compact filament lamp," whereas other authors erroneously refer to such lamps as "point-light sources," even when the filaments are as large as 1×4 mm, a dimension I hesitate to call a "point" (see Figure 3). A low-voltage, dual-filament lamp with a metered power supply (Figure 4) provides an accurate control of light intensity over a wide range, allowing a convenient method of achieving desired exposure times. To obtain the maximum benefit, an enlarging lens of highest quality is desirable.

Acknowledgment

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Incident-oblique and transmitted illumination for intravital cinemicrography

CHARLES L. SCHNEIDER

A unique point-source (1-mm) xenon (Strobex) lamp with a variable high flashing rate, appropriate for slaving to cinemicrography (Schneider, Eidt, and Schneider, 1967; Schneider and Schneider, 1968) is available. This cool-light, stroboscopic lamp can be used with the Ultropak microscope (Schneider and Meyers, 1967; Schneider, Meyers, Chaplick, and Schneider, 1967) for depth perception into living tissue. To approach the theoretical limits of resolution of the microscope, the Ultropak requires improved light efficiency and unilateral illumination to increase differentiation by three-dimensional relief.

Neither heating of the living tissue nor movement of the microscopic field is appreciable during the very short exposure with the electronic flash.

At 400 frames per second (fps), the interval between successive frame exposures is one hundred times as long as the 25-microsecond duration of the flash. At 24 fps, the interval is more than one thousand times the flash duration. Thus, each frame is a stop-motion picture in the sense of a time-lapse photograph, irrespective of the framing rate.

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In transmitted-light cinemicroscopy this strobe lamp can be focused to obtain the high resolution of the conventional microscope. Likewise, for intravital incident-light cinemicrography, the strobe can be efficiently focused into the oblique ring condenser of the Ultropak microscope.

To clarify some applications of the Ultropak for improved differentiation, comparison between these two kinds of microscope lighting is necessary.

Incident-light Microscopy with Leitz Ultropak

The ambivalence expressed by investigators about the use of the Ultropak for observation of the microcirculation is probably felt because all incident-light microscopes are inherently rather inefficient and because micrographers often do not know that in the operation of the Ultropak both "bright-field" and dark-field illumination are possible. The bright field is obtained, by reflection from the air-object interface, with dry objectives, and the dark field with immersion objectives. Only the dark field is useful in the study of the microcirculation.

The bright field is often used for viewing opaque metallurgical or petrographic specimens, particularly those with pol-

ished or etched surfaces or with both kinds of surfaces. It was for such interface examinations that this microscope was originally designed. It is also used in forensic microscopy, for example, to examine deep into the filamentous structure of paper, or into the warp and woof of cloth for comparison or identification of an unknown fragment.

While a "bright field" can be obtained by reflection, not only in mirrorlike metallurgical microscopy but also from the air-tissue interface of a biological specimen, and can be useful for study of the microscopic topography of a tissue or of an organ, yet that same reflection conflicts with deeper, focal-plane intravital microscopy. Its glare tends to degrade and, at increasing magnifications, to obscure the image formed from any focal plane of interest deep to the interface. This obscuration occurs even though the tissue is transparent through several layers, until some dense object of interest is met, such as the blood, circulating within vessels.

The Ultropak illuminator directs incident light from above and around the (narrow mount) microscope objective; important differences arise because the focused beam of the condenser is directed away from, not into, the objective lens as it is in the transmitted-light microscope.

Dark-field Ultropak Intravital Microscopy

Since the immersion objectives have a short working distance, they can be immersed into the tissue-irrigating fluid. The oblique beam from the epiilluminator strikes the fluid nearly perpendicularly to its curving surface. (The flowing physiologic saline forms a broad standing column, supported in part by surface tension, from the objective to the specimen.) Not only is the air-tissue interface, and thus its glare, eliminated, but the fluid increases the numerical aperture of the objective almost as much as would immersion in oil.

Much of the incident beam is lost, some by absorption but more by passing on through the transparent living tissue, away from the microscope. In addition, of the light that is "reflected" from the object plane, much is lost by dispersion. Light energy that falls upon an opaque object undergoes molecular absorption, and the object becomes self-luminous by reradiation of some of the energy as light, in all directions (Weisskopf, 1968). Of the reradiated light, only those rays that are directed into the aperture of the microscope contribute to the image formation. The combined light losses prevent the intensity of the Ultropak image approaching the intensity of the image of the conventional transmitted-light microscope.

The Ultropak permits microscopy into intact living tissue to a depth as great as the focal depth of the objective. The hollow conical beam from the "ring" or epicondenser is directed upon the object at a markedly oblique angle to the axis of the microscope, and it can be focused onto the selected focal plane within the tissue. For efficiency, the beam of the Model 135 Strobex lamp can be focused as a hollow cylinder, horizontally to match the Ultropak annulus. Conversely, the focused narrow beam of the Model 135A Strobex lamp, or other mounting in a special housing and focusing system (Schneider and Schneider, 1968), can be directed onto one or more sectors for unilateral or shadowed relief illumination.

These and other advantages and disadvantages combine to give differentia-

tion, and therefore an ultimate limiting magnification in terms of useful resolution, intermediate between that of self-luminous macroscopy and conventional transmitted-light microscopy. The focusing capability of the Ultropak provides intense epiillumination for microscopy with immersion objectives of ×23, ×55, and higher.

Just as in macroscopy, so also in Ultropak epiillumination, although the beam is collimated and focused, it is not possible to achieve resolution by refraction from density differences within the object because the light beam is not directed through the object *into* the microscope, as it is in transmitted-light microscopy.

In contrast to the image of the self-luminous object in the epicondenser microscope, the transmitted-light image from the conventional transmitted-light microscope is seen in reverse, as a silhouette.

Conventional Transmitted-light Microscopy

Bright Field

The image formed by the compound microscope with conventional transmitted illumination, is described in optical treatises in terms of focusing of points from the object field onto the image plane.

The description does not go on to state that the image is a reversal. The image is a differential shadow, cast by the object within the intense bright-field beam that is focused by the condenser into the aperture of the objective of the microscope. The intensity of the silhouette image, then, may approach the limit set by the light source, which, without the object, provides a uniformly intense bright field. The reversal or silhouette image is formed by subtraction from that bright field. Image detail within the shadow silhouette of the object results, in part, from differential light absorption. More importantly, differential image detail is contributed by variable refractions of rays of the transmitted beam.

Refractions, caused by local differences in density of the object, are projected as refraction densities, but the refracted rays intensify their own secondary shadow silhouettes within the silhouetted image by being projected as intensifying contrast halos of light onto one or more sides of the refraction shadows.

Thus, the transmitted-light microscope produces an enhanced reversal image with refractions that provide subtraction and reinforcement differentiations within a trigonometric shadow picture, all within the otherwise uniformly bright field that the condenser focuses into the objective lens of the microscope.

The reversal image, of course, is rendered not only in black and white but also in differential wavelength, or color, absorption and transmission.

For the bright field, the image-forming beam is limited by a diaphragm to a cone that fills the aperture of the objective.

Just as the bright-field image of the conventional transmitted-light microscope is a reversal (negative) silhouette in a bright field, by contrast, its dark-field image is a reversal (positive) silhouette in a dark field.

Dark Field

The object appears brilliantly illuminated within a black background. For the dark field, the illumination is not formed as for the bright field, by the cone of light from the condenser into the aperture; that beam is blocked by a black

central stop. Instead, the object is illuminated by a (hollow) beam external to the cone of the aperture. The image is formed only by refraction through the object (of such obliquely directed peripheral rays as would otherwise have passed externally to the objective of the microscope) into the aperture of the microscope. Were there no refractions of light by the object into the aperture, the image field would remain dark.

In the transmitted-light microscope, the conventional bright and dark fields together fulfill the opposite ranges of the definition: "An object is discerned by silhouette when the general level of brightness of all or a substantial part of the object is lower or higher than the brightness of its background" (IES Lighting Handbook, 1959).

Narrow-mount Objective Silhouette Microscope

The compound-lens system of the Ultropak can also be used as the objective and ocular-lens system, as a conventional transmitted-light microscope. Indeed, the narrow-mount objectives are so suitable for field searching and focusing within the confines of a limited-access field of an implanted window that they are used for intravital observation of tissues in implanted chambers, such as in the rabbit ear or above the hamster cheek pouch, with substage condenser or other lighting for transillumination microscopy.

Phase Contrast

The phase-contrast application of the conventional microscope similarly provides a reversal image. The required annular-beam light source is derived by insertion of an appropriate central stop within the condenser-light path. That annular beam is then divided into two component paths, which are recombined after differential passage through the specimen, whereupon they subtract from or reinforce one another, to give the well-known phase-contrast image. The enhanced differentiation of phase-contrast imagery permits resolution beyond the limits otherwise defined for the conventional light microscope.

The interference microscope similarly recombines a divided-path beam, but uses reflected instead of transmitted light (see below).

Incident-light Intravital Microscopy

Pseudo "Bright Field"

For tissue-depth intravital microscopy, the long working-distance objectives and their ring condensers, result in reflection of much light from the air-tissue interface or the air-irrigating fluid interface, back into the microscope. The general glare and the unevenness of the surface reflections, or highlights, obscure the deeper focal-plane images. In the Ultropak (and even more so, in "autocollimator" metallurgical microscopes, in which the objective lens serves double duty as an axial epicondenser), with increasing magnifications, the already low-contrast image is increasingly degraded.

In opaque metallurgical microscopy, the Ultropak manufacturer refers to the air-object interface reflection as a bright field. The air-object interface becomes the object plane. Moreover, a focused beam can be almost wholly reflected from a polished surface of the object into the objective, so that the intensity of the image may approach the intensity of the condenser beam itself. However, for present application to a depth within tissue, there is no positive cybernetic relationship between the Ultropak (interface) bright field, and the focal-

plane tissue-depth microscopy as in, for example, observation of the microcirculation. Instead, this intervening, reflected "bright field" causes an out-of-focus scattered glare, not a focal-plane reflection from which an image can be focused (as in metallurgical microscopy), and not a focused transmitted beam from which a silhouette image can be formed by subtraction, refraction or phase contrast, as in the bright field of transmitted-light microscopy. Clearly, this Ultropak "bright field" from the tissue-air interface is superimposed upon the image from the focal plane of interest. Instead of contributing to that image, its superfluous light degrades the image when the microscope is focused to any different optical plane. This pseudo bright field degrades tissue-depth focal-plane perception that would be obtainable if the bright-field reflection were prevented.

For the intravital microscopist, then, the Ultropak bright field is an artifact that too greatly degrades an intravital image that is of inherently low contrast. It is probably mainly for this reason that the Ultropak microscope is not suitable for study of the microcirculation when the low-power, dry, long working-distance objectives and their ring condensers are used.

A "very oblique condenser" (with extension tubes appropriate to each low-power objective) is offered by the manufacturer to minimize the direct reflection into the objective. A satisfactory way to remove the offending glare caused by the air-tissue surface is to eliminate the interface by using the immersion objectives (see "Dark Field," above).

An unsatisfactory way to eliminate the air-tissue interface is to interpose a dipping cone; a separate one is provided for each of the long working-distance ×3.6 to ×22 objectives. The cone dips into the tissue-immersion fluid, and thereby in essence provides a (thick) cover slip over the tissue. However, while removing the air-tissue interface, these dipping-cone cover slips substitute an air-glass interface, and thus superimpose a somewhat less intense bright field from the dipping cone itself, which is reflected back into the microscopic objective.

That bright-field reflection, too, tends to obscure the already low-contrast image of a subsurface focal plane.

Differential Interference-contrast Microscope

The greatest obscuring of perception of a focal-plane tissue image from deep to the surface is produced by the differential interface-contrast microscope, which displays, in high relief, minute differences in surface elevation (Gross and Hoffman, 1967).

The Nikon Francon en Yamamoto incident-light differential interference-contrast microscope provides the expected enhanced, color-contoured relief image of the air-tissue interface, for example, of the lung. But at all focal depths beneath the surface, visualization (for example, of the vascular tree or of the circulation within the vessels of that tree) is totally obscured. Thus, the interference pattern from the tissue interface obscures the image from any deeper tissue focal plane to a far greater degree than does the glare from the Ultropak microscope.

A cover slip or a layer of tissue-irrigating fluid applied over the air-tissue interface provides another high optical-contrast interface, from which the interference pattern similarly obscures visualization of deeper optical planes. Conse-

quently, visualization of even the pleural surface, which had been predominant when it formed the air-tissue interface, is excluded.

Interposition of irrigating fluid as an objective immersion medium eliminates the air interface and its interference reflection. However, there is then not usually a high-contrast interface surface of interest within the tissue for interference-contrast microscopy.

Discussion and Conclusions

The reversal image of the transmitted-light microscope has two outstanding characteristics: Its intensity may approach the intensity developed by the external-source focused beam of the microscope condenser, and the silhouette of the object into the microscope as a geometric shadow pattern is further elegantly differentiated by subtraction and reinforcement silhouette refraction. Both improve the ultimately obtainable resolution of the microscope. Except for surface topography imagery, the image intensity of the self-luminous intravital object of the Ultropak microscope cannot approach the intensity of the image of the condenser beam of the transmitted-light microscope.

There exists a considerable range of overlapping of object size in macroscopy and in Ultropak microscopy; by removing the eyepiece, this microscope with its exquisite epiillumination can be used as a macroscope. However, in addition to the advantages of the immersion objectives of the microscope itself, and of the precision condensing of the light onto the focal-plane object field, use of the eyepiece provides a flat-field image and permits a focusing telescope to be attached for cinegraphy.

The high-power "water-oil" Ultropak objectives (by immersion into the tissue-irrigating fluid, for example, that flows over the lung) improve tissue-depth dark-field intravital microscopy, and eliminate interfering interface reflections.

One-sided, or "sector," illumination provides three-dimensional relief, and thereby improves differentiation. Perhaps differential sectors of color illumination could provide color-relief contrast.

The infrared content of the xenon strobe lamp is inherently low and tends to be absorbed by passage through the focusing lenses. Regional heating of the tissue is minimized by the precision convergence of the beam onto the microscopic field and by divergence of that beam beyond the focal plane, but most importantly by the short duration of the strobe flash.

In studies of the blood circulation, useful object differentiation is obtained by adding optical contrast materials, for example, methylene blue to the circulation, or colloidal carbon to foreign embolic particles that are to be infused. Appropriately timed infusions of dye (or of colloidal carbon suspensions) render visible the deposition of fibrin out of the circulating blood, during "fibrination." The fibrin deposition would otherwise have been apparent only by the absence of red blood cells, which of themselves provide color density contrast.

Acknowledgment

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When words are all you have

ROBERT A. HAMILTON

A certain five-word sentence has found its way into so many texts on writing that it is now a truism: Good writing is not easy. And I agree.

However, I do not like the implication. It sounds too much like a warning about something you should stay away from. No single boon to man has come easily, and even seemingly simple operations need to be learned. Generally, the easier the performance the shoddier it is.

There is another aspect. Not everyone can become a virtuoso on the violin. But a person who has an average ear can, with lessons and practice, learn to handle the instrument properly, and eventually become a passably good violinist.

So my comment is not a refutation. I simply mean that there is no reason why writing should be easy, and that it is entirely possible for a person who really has something worth saying to achieve an adequate performance.

Practice, with direction, aids immeasurably in increasing your ability to write. Write often, and refer to your high school or college composition textbook at the slightest hint that help is needed. The best papers that have come my way in the past 25 years have been written by a man who had to write a composition in school every day. But even now he prunes and polishes every paper he writes.

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There are, of course, several types of journal articles, and not all my remarks are meant to apply to all kinds. The very colloquial style of the article you are now reading should just about never be used in the average paper submitted to the *Journal*.

Let us, then, consider how one type of *Journal* article, a new method in biological photography, might be written.

First of all, gather your material, all the notes you have made and the illustrations you plan to use. Question this material. Spend at least one evening thinking about it, about what other people have done in the field, and where and why you may disagree with them. In this way, spur your critical faculty so that you will be alert while you write. At the same time, the plan of the paper will be developing in your mind.

Now read the advice to contributors found on the inside back cover of each issue of the *Journal* and check the latest issue for any particular point about which you are in doubt. When writing by hand, use a pad of lined paper 8½ by 11 inches. Just write on every other line.

Now start to write. Begin at any section whatsoever. In my own practice, I sometimes start with material that eventually will be inserted half or two-thirds of the way through. Some parts of your paper may come to you so readily that you will be encouraged by the mere fact of having started. Straight description is usually not hard to set down. As you write, you gain the impetus that is needed for writing the harder parts.

When you have finished this first spurt, steel yourself for the next move. Though it is true that you are imparting information, you are only doing it so that someone else can receive it. So, now comes a tricky feat. You have to do an about-face. From now on, you have to write in answer to a continuous question: How can my reader best get the information out of what I write? You have to write through your future reader. He will want to know how you found out or devised the subject of your paper, how you first tackled your task, and maybe what went wrong somewhere along the line. You will probably continue your writing with an account of how best to assemble your apparatus. Pause now. Ask yourself what else there is that the reader needs to know. Make a plan for your complete paper. First, list main subjects. Then arrange the subjects in proper order. Include lesser subdivisions, and if you like, at this time, set down headings and subheadings. Your plan will probably be quite short. For most papers it should be. Turn back to your notes. Has anything been left out of your plan?

Read what you have written, but do not change any of it yet. Continue writing according to your plan, but do not spend much time at the opening sentences or the final paragraph. You may be surprised to find that the setting down of your material is not so hard as you thought it might be. You may also be surprised at how soon you finish. Now fit in the first words you wrote. You have come to the end of your first draft.

Check your notes once more and insert any points you may have left out. Fill in any description that may not be complete. You will know now why you wrote on only every other line. If you are quoting, make sure the words are exactly as the author wrote them.

Now get down to serious work. Read your first draft. Test it against your plan. Then work the other way around. See if you can improve your plan. Ask yourself about your order of bringing in the sections. When you start a different topic, begin a new paragraph. But try to introduce this paragraph with a sentence that connects it to the previous one. In this way you gain smooth continuity. Change sentences or phrases, delete what now looks like padding. Be ruthless in your criticism. Tackle fine points too. Use your Webster if you are in the slightest doubt about how a word is spelled. For the exact and most effective word, go to Roget's *Thesaurus*. Check your grammar and punctuation. Enter headings, and remember that they do not form part of the text. The first sentence of a section must stand absolutely on its own verbal feet.

Now work, harder than ever, to obtain the most inviting introduction and the strongest and most logical conclusion.

Take a last look at the illustrations, if you plan to have any. They are a very important part of your paper. Are the photos of the very best quality for reproduction? Are you sure that what is shown in one picture is not actually in another? Do the cut lines under the illustration tell just what you see in it, or do they add words that should appear in the text? If a table is tiny, could the information go just as well in the text?

Finally, read once more the advice to contributors in the current issue of the *Journal*. See that everything you have written so far abides by this advice and bear in mind other recommendations that will apply when you are typing the man-

uscript. Be sure that all the figures and tables are mentioned in the text and that you have used the preferred indicators for authors you have referred to. Make up the list of references, if you have not already done so.

You may now type your manuscript. If you have been very careful, it may be your final one. But many authors come to the conclusion that this typing, with all the changed material that went into it, represents little more than a practice effort. Whatever you decide about a complete revision, at some time you will have a typed manuscript that you believe is ready to be sent to your *Journal*.

As you type the address on the envelope it might be well for you to become a little reflective. Much of your reputation as a biological photographer may be contained in what you slip into that envelope. A final reading? Perhaps. From the moment you began your paper you have had no camera, lens, photographic plate, developer, enlarger . . . You have had only the material of written words. Every single word and punctuation mark is important. How they are used makes all the difference in your manuscript.

Put it in. Seal the envelope. It's a chance we all take.

letters to the editor

You are invited to contribute to this new department comments related to the activities of the Association, the *Journal*, and the profession in general.

It is the intention of the editors to develop this department into a discussion forum, and so offer an opportunity to criticize our programs, the governing of the affairs of this Association, and the material published in this journal. Many ideas discussed in the papers may often be further expanded or improved through constructive criticism, and theories that do not really work may be corrected.

The editors hope that the readers of this publication will take advantage of the opportunity to express their opinions. Letters considered of general interest will be published in this department, over the writer's signature; other letters may be referred to the attention of the House of Delegates, the Board of Governors, the Executive Committee, or the group concerned. In the case of criticism of a paper published in the *Journal*, the author of the paper will, of course, have access to this department for the defense of his point of view.

editor's choice

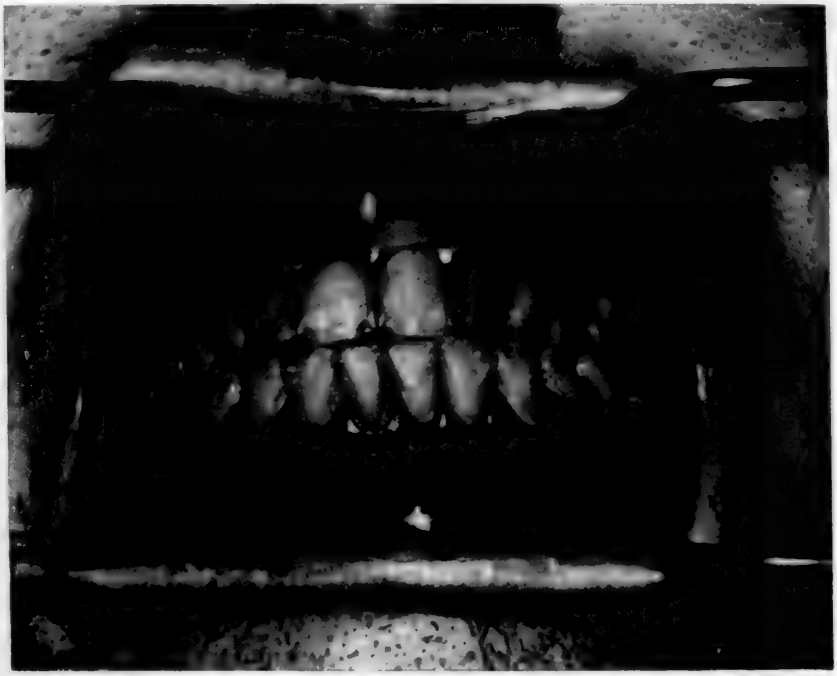
Lead Poisoning

This photograph, by Joseph Merva, taken on 4 × 5-inch Kodak Super Panchro Press Type B film, with a No. 5 flash bulb light, f/32, at 1/50 second, and printed on polycontrast paper, was accepted for showing at the Scientific Exhibit, 38th Annual Meeting.

Mr. Merva was a medical photographer at the Veterans Administration Hospital, Cleveland, Ohio. It has been learned with regret that Mr. Merva died last October.

Mule Deer Fetus

The original color transparency of this black-and-white photograph taken by Donald H. Fritts, Montana Veterinary Research Laboratory, Montana State College, Bozeman, Montana, was accepted for showing at an earlier Annual Meeting and received an Honorable Mention Award.



Lead Poisoning **Joseph Merva**

Mule Deer Fetus **Donald H. Fritts**

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AIDS TO COMMUNICATION ISSUE

MEDICAL AND BIOLOGICAL ILLUSTRATION

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TECHNOTES

Exposure Determination

One of the characteristics expected of a professional photographer is his ability to achieve technical excellence in routine, as well as unique or difficult, circumstances. Correct exposure is one criterion of excellence that is obvious and easily appraised by other professionals or laymen.

The variety of tools and techniques now available makes incorrect exposure rarely excusable. Mastery of pure technique could free biophotographers for the creativity and imagination required for production of scientific illustrations that would more effectively enlighten and inspire student and practitioner alike. In the typical scientific publication of today innovation is too often missing.

Correct exposure in daylight, or with floods, spots, or existing light, requires one technique; flashbulbs and electronic flash require a totally different technique. The subject of exposure by flash will not be included in this article.

For general photography, the first tool for determining exposure is a dependable light meter, sensitive enough to encompass the range of brightness normally encountered and versatile enough to include the full range of film speeds, shutter speeds, and lens apertures used.

Whether incident or reflected light measurements are taken, calculations should result in identical combinations of lens aperture and shutter speed when the meter is used as recommended.

For predictable, repeatable results, meter readings should be made by a consistent technique, confirmed by the results of test exposures.

For special exposure problems, which in photography of scientific projects somehow become the rule rather than the exception, the photographer may devise his own solutions.

One such solution, by Louis W. Nichols of the Mayo Clinic Section of Photography, provides a dependable method of determining the exposure for reproduction of enlarged or reduced color transparencies. The aim was to reduce the calculations required by density variations, filter factors, and bellows extension. When the probe of an electric optical-density meter, the Welch Densicron, was placed at the ground glass, the brightness of the ground-glass image was controlled by adjusting the lens aperture until the meter needle was deflected to 1.1. Tests at that aperture proved that a one-second exposure on Type B Ektachrome sheet film yielded the desirable density. All subsequent variations of magnification, filtering, and density were calculated automatically, and the reciprocity factor was held constant by use

of the same time interval. Subsequently, refinements of this method led to its use in photomicrography, as well as in exposing flat artwork, X-ray film originals, and some three-dimensional originals such as cultures in petri dishes or test tubes, and wax models. Measurement of most transilluminated originals is from a highlight area; for other originals the meter probe is directed at the ground-glass image of a neutral test card in the scene.

The technique is a forerunner of through-the-lens meters now found in many miniature cameras. Its advantage lies in its use with ground-glass cameras, which do not have such a built-in exposure system.

Lights positioned to backlight a subject have no effect on the exposure; they are only used for lighting effect. They should be turned off when the light intensity is being measured, regardless of the method used. Backlight reaching the meter's light sensor would indicate an abnormally high light level, which would cause underexposure.

A reliable indicator of correct exposure for sunlit subjects may be found in the ASA film-speed rating. Use the recommended speed rating for the denominator of the shutter-speed fraction (that is, 1/400 for Kodak Tri-X Pan, 1/25 for Kodachrome II Daylight) and use $f/16$ as the lens aperture. In bright, clear sunlight this combination of shutter speed and f-stop would be the correct setting. Alternative shutter speeds may be used with corresponding aperture adjustments. The principle is useful when checking the performance of a meter, too. Make a reading on an average subject in bright sunlight. If, for example, the meter was set for an ASA speed of 200, the shutter speed opposite $f/16$ should be 1/200 second. If the reading indicates a different combination, one of two things is wrong: the meter is being used improperly or it is out of adjustment. Remember the constants. The ASA speed rating for film makes the denominator of the fraction and when the meter is used properly that shutter speed should indicate $f/16$.

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Received 31 October 1968

Rear-screen Projection

Rear-screen projection provides light for the room, which facilitates note taking and reference to printed material, and at the same time it displays a bright image on the screen. It also eliminates from the conference room the projector noise, and power and speaker cords and their hazards. The position of aisles does not have to be considered in relation to the projected beam, and a person walking in front of the screen cannot obscure the picture. Lighted classrooms keep the audience awake and make it possible for the instructor to observe the reaction of the audience.

The rear-screen projection assembly described in this article was built as an experiment to determine its effectiveness for uses in classrooms. Included was a partially self-controlled projection whereby the instructor could turn on and off the two Carousel projectors or a 16-mm

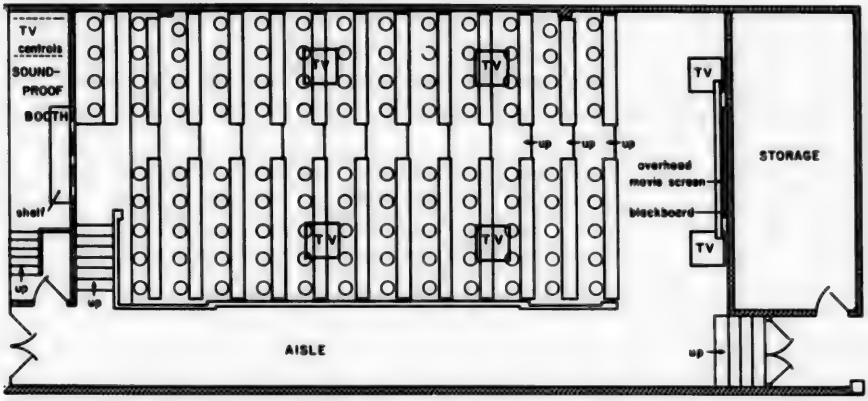

Figure 1. Plan of auditorium before rear-screen projection was installed.

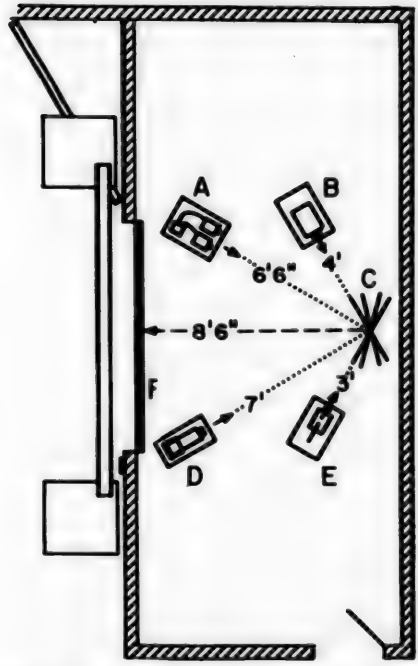

Figure 2. Rear-screen projection room: *A*, two Carousel projectors with 3-inch lenses and dissolve unit; *B*, overhead projector with 18-inch lens; *C*, mirror 36 by 48 inches, on pivot; *D*, 3¼ × 4-inch lantern slide projector with 6.5-inch lens; *E*, 16-mm projector with 1-inch lens; *F*, Polacoat rear screen 87¼ by 92¼ inches.

movie projector. A power switch for both projectors and remote control to focus the Carousel projectors were located on the wall to the right of the screen. The instructor had only to turn on the power switch when he arrived at the point in his lecture where he needed the slides or movie. Of course, he could stop at any point to answer questions from the audience by simply detaining the next slide or stopping the movie projector with the on-and-off power switch. A projectionist was needed only for setting up the apparatus or operating the projectors if slides and movies were both needed for a single lecture.

The room (Figure 1) was originally designed to seat 112 people. It had front-screen projection, TV monitors hung from the ceiling, a blackboard, and a small stage, which for our purpose had to be made enclosed. A rear screen also had to be installed.

The projectors were standard, except that the focal length of the lenses were changed (Figure 2) to compensate for the distance from projector to mirror to screen. A 16-mm sound projector with a 1-inch lens, two Carousel projectors

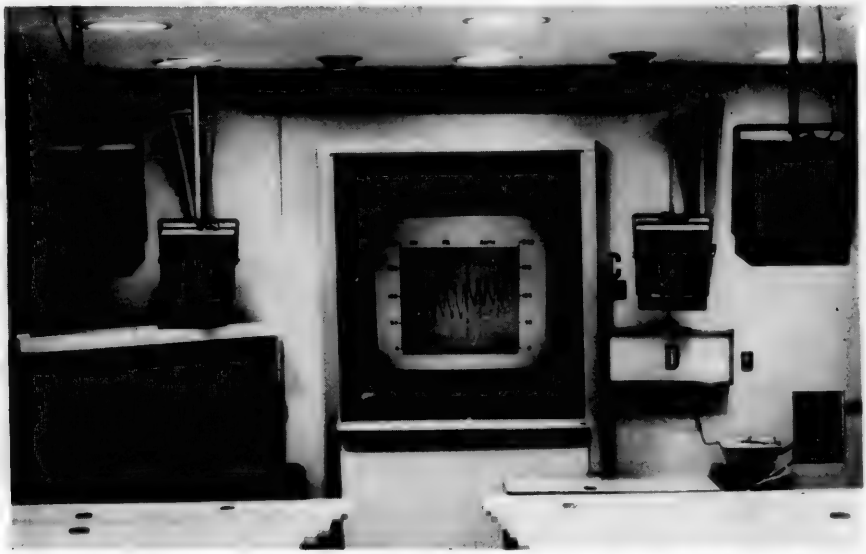

Figure 3. Auditorium with slide on rear screen in fully lighted classroom: *A*, power switches to amplifier and to all projectors; *B*, lead-out cord for Carousel remote control; *C*, porthole for projectionist to observe audience and instructor; *D*, X-ray view box.

with 3-inch lenses and a dissolve unit, and a projector for the 3¼ × 4-inch lantern slides, with 6½-inch lens were needed. In special cases an overhead projector with an 18-inch lens could be used from the rear of the screen. A television image could be projected with a special device made for this purpose.

The rear screen was a Polacoat screen, 87¼ by 92¼ inches (Figure 3) with a matt surface on one side and a glossy surface on the other. It could be used from either side, but to protect it from marks caused by pointers and fingers the matt surface was turned to face the mirror. To avoid reflection of the room lights from the glossy surface, the screen had to be tilted downwards.

The mirror was mounted on a pivot, and its height together with that of the projector lens was adjusted to correspond with the center of the screen. For best results a front-surface mirror of good quality should be used, but for us a regular rear-coated mirror produced good results.

The future of this technique will need to await a longer period of use. Those who have put a little more time and effort in setting up their slides for rear-screen projection, are pleased with the results. Plans in future classrooms for the School of Dentistry call for a central rear-screen projection with connections to several classrooms.

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Received 30 August 1968

Low-budget Exhibit Production

Producing a scientific exhibit that will be both effectively informative and artistically competitive need not be considered a dreaded task. The budget-conscious investigator can avail himself of the services of a scientific communicator whose past experience has made him aware of techniques that can lower the expense without lowering quality or effectiveness.

If the communicator is given a free hand in structural as well as artistic design, a good beginning has been made. The scientist should also heed the communicator's request that the amount of words be cut to a minimum. Printed material in the form of folders, mimeographed sheets or brochures should supplement the exhibit. Proper utilization of the exhibit surface is achieved by presenting large, bold graphics that attract the viewer and allow him to obtain a grasp of the portrayed technique from a distance of 6 to 10 feet (Figure 1).

Prepare a preliminary sketch showing the size and shape of the exhibit (Figure 2). After showing the sketch to the requester and obtaining consent for production, make a scale drawing on large drafting paper, showing in detail the size, shape, and positioning of all drawings, photographs, transparencies, lettering, and anything else needed on the viewing surface. Color charts from a local supplier of latex paint will help in deciding basic tones to be used, and these should be noted on the drawing with colored pencil. When finished, this scaled, colored "blueprint" will direct the communicator as he prepares the final exhibit (Figure 3). If time permits, make with stiff cardboard a model of the exhibit at a scale of about $\frac{1}{8}$ inch. A rapidly colored and sketched detail will present a model that will convey in concrete terms the exhibit's configuration (Figure 4). This added step allows the requesting investigator to better visualize the finished product, and it is sometimes required by the sponsor of the exhibit. If carpenters are subcontracted for woodwork construction, they should be provided with

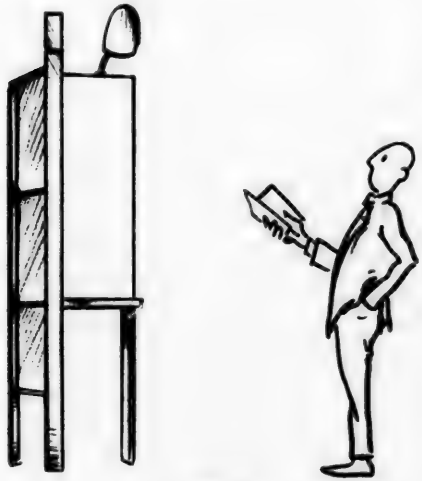

Figure 1.

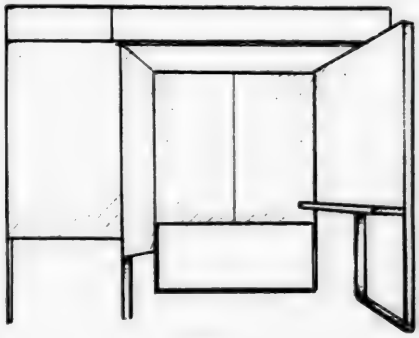

Figure 2.

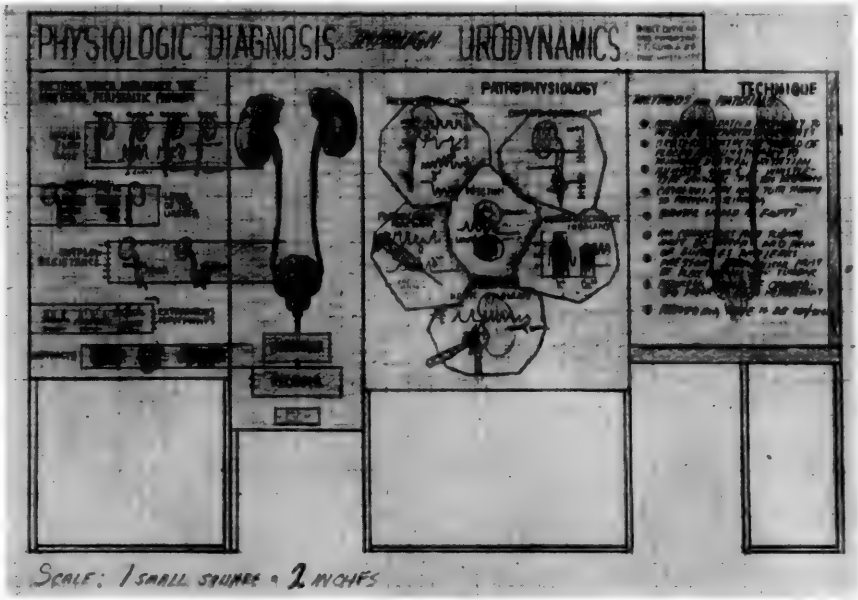

Figure 3.

Figure 4.

a three-dimension model of the construction drawings.

To cut costs, a single feature should serve a dual purpose. The exhibit's wooden framework can also support weight or provide "legs" for the display. Finished pine or fir ¾ inch thick and 3 inches wide has been found to serve this purpose adequately. The framework is simply allowed to run continuously from the top of the exhibit to the floor (Figure 5). In this instance, a third purpose is also met by use of a framework of wood at least 3 inches wide. If the exhibit is to contain transparencies, the wooden frame can serve as a base on which to mount the porcelain electrical sockets for the transillumination light. The framework just has to form a cubicle where the transparencies are to be placed. Light bases of the screw-in type are mounted on any one of the inner surfaces of this cubicle, and tubular, low-heat, frosted, incandescent light bulbs are installed. A multiperforated, white-painted piece of masonite is affixed with hinges and latch to form a reflective back for the now-finished light box (Figure 6).

One-eighth-inch tempered masonite affixed to the front of the framework serves as a surface for the exhibit data. This material has proved satisfactory in every respect: it is light in weight, receives paint quite well, has adequate strength, and maintains a smooth surface when the construction nails are countersunk and the holes are filled with plastic wood. Not only does minimum weight facilitate general handling during production, but later on it makes for ease in crating and assembling, and saves money in transportation charges. In fact, the three items that save money, judiciously selected framing wood, masonite, and tubular light bulbs, also are weight-saving devices.

Simplicity of crating and assembling is just as important as ease of handling. By restricting single panel widths to the standard 4 feet, light weight and rather small bulk make assembling easy. One man can lift and crate the panels, provided there are not very many transparencies and not much hardware. Quarter-inch holes drilled in the wooden framework to accommodate wing nuts and bolts ensure easy mating of panels

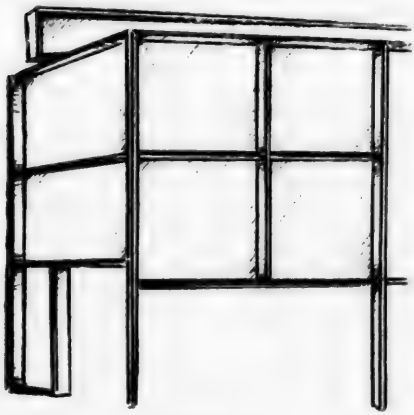

Figure 5.

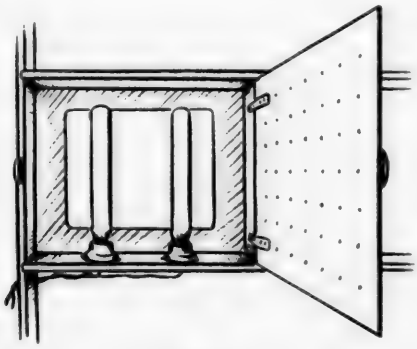

Figure 6.

(Figure 7). Bolting the title board to the top of the U-shaped display provides additional stabilization (Figure 8).

Surface lighting, as well as transillumination, must be considered. Because of the U-shaped design, the separate header or title board can display the exhibit name or title and also contain fluorescent tubes for illuminating the viewing surface (Figure 9). The same effect can be achieved by allowing the title board to protrude beyond the surface; the hidden lights then reflect back onto the viewing area. Supplementary floodlights can be obtained at commercial display companies. Bullet-head Amplex units with flexible supports and L attachments are economical and of light weight (Figure 10).

Last to be considered is a shipping crate. Construction plans for the crate should be drawn at the time the detailed plans for the exhibit are prepared. Carpenter subcontractors can then construct the crate while the exhibit is available, and so ensure a proper fitting. By plan-

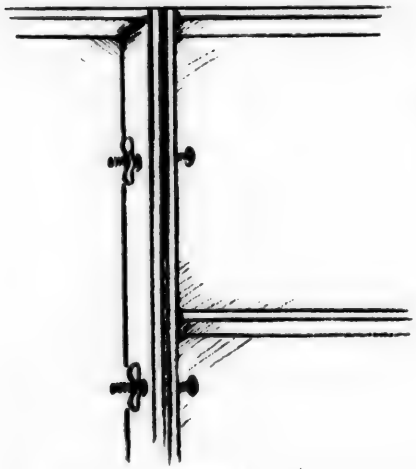

Figure 7.

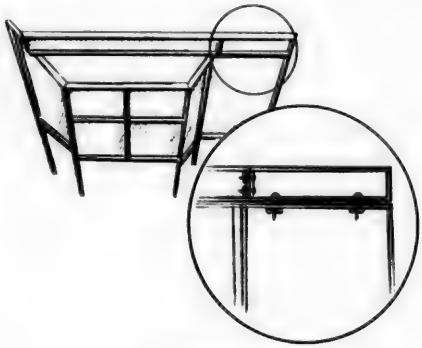

Figure 8.

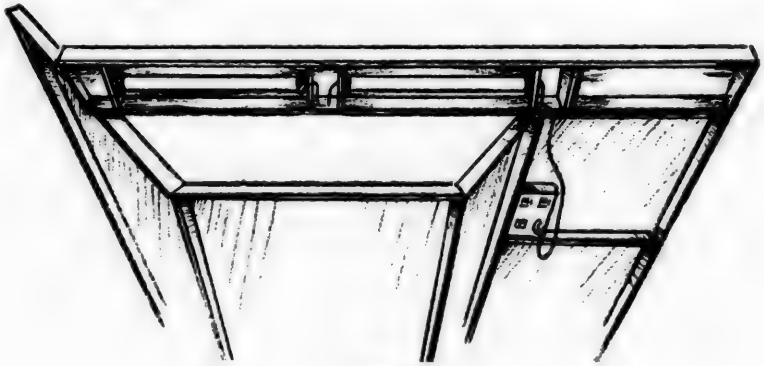

Figure 9.

ning panels for a maximum of 4 feet in width and 6½ to 7 feet in height (including legs or supports) a compact shipping crate can be made. It should be designed for loading while in an upright position so that panels slide in and out in the same position they occupy in the final assemblage (Figure 11).

Figure 10.

Felt-lined runners at the crate's top and bottom facilitate crating and minimize slipping of panels or other damage during transit. Space should be designed to accommodate such items as supplementary lights, flourescent tubes, and electrical cords. Packing material such as cardboard or wadded newspaper helps to ensure a tight fit after the side-hinged door is closed and fastened. Plywood of ⅜ inch is durable and of light enough weight for crate construction. A simple sketch pasted to the inside of the door of the crate, showing corresponding numbers for respective panels and proper slots in the crate, aids in packaging by persons unfamiliar with the exhibit. A photograph of the assembled exhibit affixed at the back of one of the panels also helps in the assembling of the exhibit after it reaches its destination. Small containers of touch-up colors and an inexpensive water-color brush to care for minor nicks and abrasions should also be included.

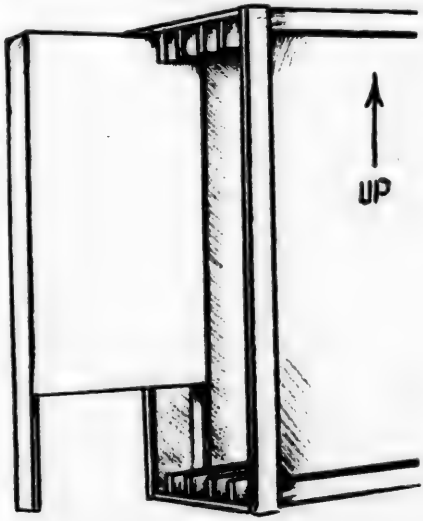

Figure 11.

A scientific exhibit (with shipping crate) constructed and completed according to these general guidelines, and containing about 60 square feet of viewing area (or 12 linear feet), can be produced for less than $1000. The exact figure depends on the number of transparencies, the bulk of electrical hardware, the complexity of scientific drawings, and the volume and type of photographic prints. Such an exhibit, though rather inexpensive as compared with commercially prepared displays, can still rank with the ribbon winners at large meetings. A medical exhibit that I prepared, and exactly the same as the one I have described, was recently awarded prizes at national medical meetings. In April 1967, the exhibit entitled "Physiologic Diagnosis Through Urodynamics" won second-place honors at the Southeastern Urological Convention in Miami, Florida. In May 1967, in competition with over sixty medical and other scientific displays at the American Urological Convention in New York City, the exhibit was awarded first prize in the category of laboratory medicine.

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The Possible Use of Holograms in Biological Photography

The ability to capture nature as man sees it in three dimensions has been sought after since primitive men drew animals on cave walls. This quest became greater when, in 1837, Niepce made the first photograph.

In 1948, Dennis Gabor attempted to solve distortion problems in the electron microscope with a concept now called "Gabor holography," and he came close to realizing man's dream of a distortion-free image (Gabor, 1948). But the search for three-dimensional effects continued until 1963, when two researchers used the laser, the most perfect coherent light known to man, to produce holograms as they are known today (Leith and Upatnieks, 1963).

Many questions come to mind when a new technique is announced. What is it? How does it work? And more important, does it really work? And, if so, does it have any applications for us as scientific photographers? An attempt to answer these questions follows:

Does it really work? To quote one researcher, "The images are three-dimensional in every sense of the word. They exhibit parallax and depth of field, provide stereo images, and are visually indistinguishable from the original scene" (Morrow and Dessel, 1966). This opinion is shared by all who have had experience with holography.

Next is the question of applications in our area; that is, does it have a place in biological photography? Yes, it does. Holography has already been used with biological specimens, and the results in photomicrography have been excellent. Institutions such as the State University of New York and the Harvard Medical School and even the American Optical Company are working in this very area (Pennington, 1968).

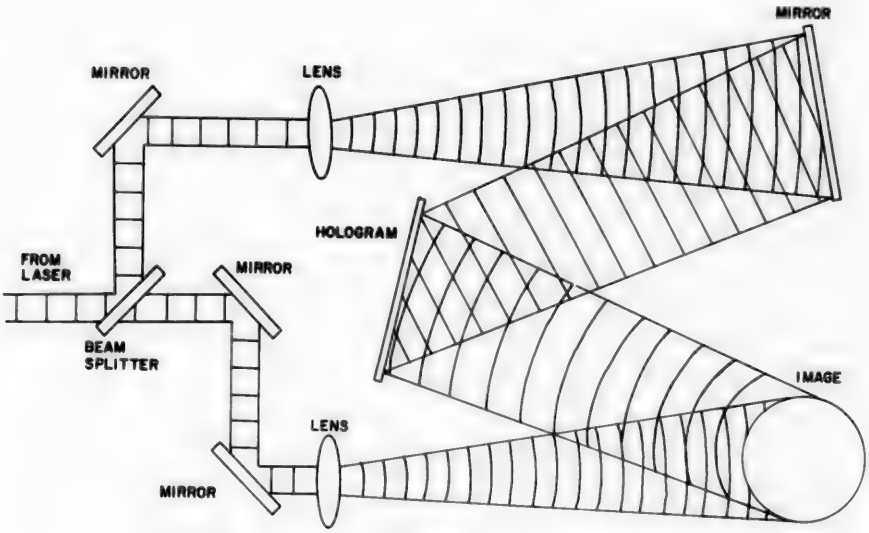

Figure 1.

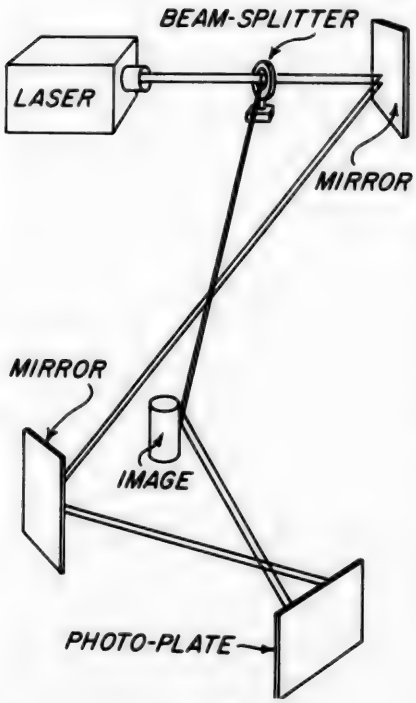

Figure 2.

The hologram of the specimen is made first, then the holographic images are photographed under very high magnifications. Used in this manner holography is no longer restricted to a very small depth of field; the entire specimen can be focused, and it does not have to be thinned down to an almost two-dimensional state or even frozen. In addition to regular photomicrographic techniques, phase contrast, dark field, and even polarization can be used. These and other advantages, mentioned later, make holography especially important in our field.

What the technique is and how it works can well be considered together. In conventional photography the picture is, of course, made by the light intensities from a subject passing through a lens and forming the latent image on film. Holography, however, records not an image of the subject, but the interrupted light waves reflected from the subject to the film or plate, thereby forming a wave-front construction.

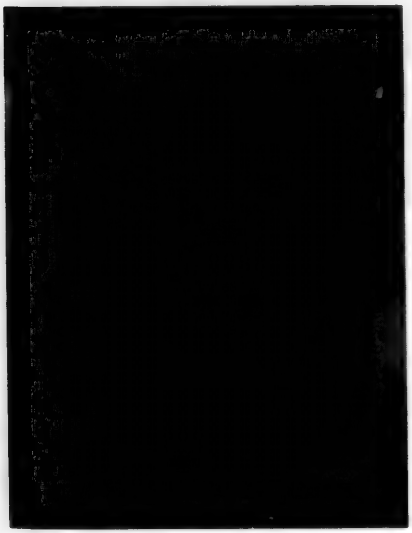

Figure 3.

A hologram is made by either using two lasers or splitting one laser into two beams, as shown in Figure 1. One beam proceeds to a conventional photographic plate or film, and the second beam reflects off the subject on to the same photographic plate as a reference beam. Figure 2 shows the physical setup.

The exposed plate or film is then developed in a regular manner. Figure 3 is a conventional print of the developed hologram. The meaningless patterns of ripples represent the interference of the two beams. Their densities are governed by the light arriving at the film plane in or out of phase.

To produce an image of the subject, or in holographic terminology to "reconstruct," the reference beam alone is used. A rear-screen projection method is used, and the image appears behind the screen rather than on it (Figure 4).

Holography has many possibilities. Theoretically, a very high number of separate images can be recorded on the same film by simply changing the angle of the beam or film. Holographic motion pictures have been produced in this manner by taking many images of the same subject, slightly moved, on a rotating film. Rotating the developed hologram in the reference beam reconstructs the moving image. The use of holography for television has also been proposed (Pennington, 1968). Multiple exposure may be used for precise measurements of

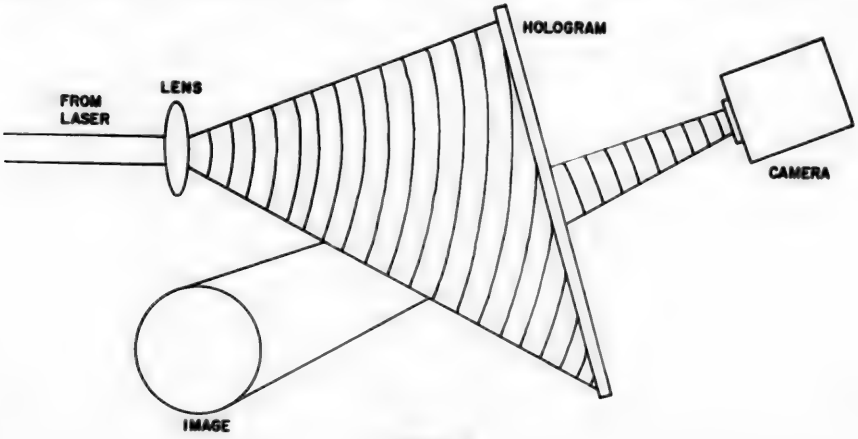

Figure 4.

movement or changes in the subject. Any changes or movement between exposures shows as light and dark interference fringes (Gradian, 1967).

Color holograms have been produced by the multiple exposure technique. The film is consecutively exposed to light in three different colors, emitted by three different lasers.

Because holography is, in a sense, lensless photography, the quality of the lens is of no importance. Lenses are used only to control the spread of the beams, not to control the light coming from the subject to the hologram.

When holography will become simple enough and economical enough for regular use in scientific photography is uncertain, but I would say in five to ten years. Kodak already has a special film for it and reference material to go with it; so it could be sooner. In any case, we had better look at it very hard and keep up with it, for it does hold many answers to problems photographers have today. I predict that for us in the field of science it will be the photography of the future.

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Photokina 1970

The organizers of Photokina, an international photo and cine exhibition held biennally in Cologne, Germany, have announced that the 11th Photokina will be held from Saturday, October 3, to Sunday, October 11, 1970. This fair will then have been in existence for 20 years. Preparations are being made to offer new and more interesting features in 1970.

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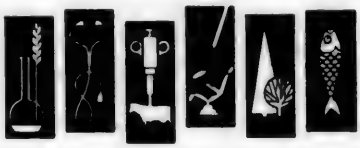
SHOPTALK



in the natural sciences

Field Photography of Nocturnal Arthropods

In daylight hours the field photographer of arthropods has a choice between natural and flash lighting. Nocturnally active subjects, of course, demand the latter treatment. The lighting objective in this case is not so much the simulation of natural lighting as it is the recording of the natural appearance of the subject when artificial light is put on it. The difference, let us say, might be between portraiture and the phototrapping of burglars. Such night photography presents three main problems: locating the subject, composing and focusing the image, and making the exposure. I will discuss these in turn.

Nocturnal arthropods seem to have one of two basic behavioral patterns. They are either silently going about the business of food collection, or they are loudly announcing their sexual availability. Finding the quiet subject, regardless of its activities, is largely a matter of knowing the creature's habitat and habits and then looking for it with a flashlight. The noisy ones are more quickly located by simple sound-ranging. The searcher chooses among the available stridulators a particular animal to trace. He listens carefully, slowly moving his head from side to side until the sound seems equally loud in both ears. General direction is thus established. He then moves slowly and silently to close the distance somewhat. One or more additional sound-ranging stops may be needed to pinpoint the location of the subject within about a foot of it. If at any time the animal ceases stridulating, a wait of a minute or so will usually be all that is required for the hunt to be continued. When final sound-ranging has closely pinpointed the subject, a flashlight is beamed in the correct direction and the hunt finished by sight.

With the subject in sight, the second problem is ready for solution. The flashlight, still shining on the subject, is passed to that invaluable ally, the assistant. The photographer will have previously prepared for the final approach by taping to the bottom of his camera a penlight, preferably of the gooseneck type, which has the bulb out on a flexible extension. This light is so mounted that its beam crosses the camera axis at the point of prime focus for the magnification to be used (Figure 1). The camera lens has been adjusted

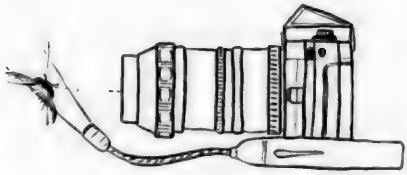


Figure 1. A single-lens reflex camera, in this case a Nikon-F with a 55-mm Auto-Micro-Nikkor lens, preset at × 1. A gooseneck penlight (Creative Playthings, Inc., Princeton, N.J. 98540, 68/69 catalog number KR-116, $1.95 ea., or KR-1166, $10.00 per six pack, plus postage) has been taped under the camera to direct the light toward the point of lens focus.

earlier to the magnification desired, and focusing is accomplished by moving the camera. With the penlight on, and the subject jacklighted by the assistant's main flashlight, the approach is made. Once the penlight is centered on the subject, the main light can be put out. The penlight beam will be found entirely sufficient for both composing and focusing. Fortunately, most nocturnal creatures seem quite willing to sit quietly in a beam of light while all this goes on.

Actual flash exposure of small subjects is most easily accomplished by reversing the normal flash computation formula. For this use the aperture will be known, being usually the smallest one available so as to obtain sufficient depth of field. By normal means the effective aperture is obtained, and the correct flash-to-subject distance is obtained by dividing the guide number by that effective aperture. It may be necessary to find by experiment the correct guide number of one's unit at these close flash distances, since conventional flash units are not designed for close-up use. With the subject roughly framed in the viewfinder of a single-lens reflex camera, the easiest procedure is to place the flash unit at the

Figure 2. A katydid photographed at night with the equipment and setup described in the text.

correct distance, using an angle of approach that will yield a good lighting effect, hold the unit at that place and angle with one hand, and then with the other hand position the camera for final composition and focus. With the pressing of the shutter release the job is done.

By use of the formula above, flash-to-subject distance equals guide number divided by effective aperture; the result will be in feet and tenths of feet, not inches.

Either ordinary M3 flashbulb units or electronic flash units can be used with equally good results, but if the former units are used, the eyes should be closed briefly at the moment of exposure in order to avoid a half hour or so of subsequent night blindness. With practice, this temporary blink will not affect the quality of the results.

For close-up flash, whether by day or night, the flash unit is not normally bracketed to the camera. Rather, the camera is held in one hand and the flash in the other, the two being connected only by the synch cord. This allows great flexibility of choice of lighting angle, especially with moving subjects. It does require a certain minimum level of two-hand coordination. Results of careful work, however, are usually worth while (Figure 2).

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in dentistry

The Function of Photography

Dentistry has been slow to take full advantage of the numerous possibilities that still and motion picture photography have to offer. Most dentists regard photography as a hobby and do not wish to mix it with their profession. As late as 1950, it was a novelty to attend a dental meeting that was well illustrated with slides. The program that emphasized illustrated lectures began to show the best attendance and interest. It is not necessary to enumerate the many advantages that a presentation illustrated with slides, motion pictures or television recordings has over the one that is illustrated with blackboard drawings as the lecture progresses.

Figure 1.

The oral reconstruction specialist, the prosthodontist and particularly the orthodontist should find it next to impossible to render a complete diagnosis and analysis of a case without adequate photographic aids or a good substitute.

Figure 1 shows face masks, used by a prosthodontist, Dr. Kyle, to demonstrate protruded upper pyorrhetic teeth and the effect of a prosthetic appliance (denture). The masks are the same size as the face of the patient. The doctor does not use photography. The masks are good, but they create problems. They require much storage space and are bulky and heavy for transportation.

During the thirties, as the use of both black-and-white and color 35-mm films gained popularity for scientific application, the Argus Company placed on the market a camera with a ground-glass focusing back, mounted on a stand with 2 lamps for use with 828 film. I also used this equipment which was moderately priced. The S. S. White Company lost no time sending out folders telling of the virtues of the camera and announcing courses in mouth photography, conducted by Rollin King in Los Angeles.

Many types of cameras and accessories have come and gone since that day to help us "snap a picture" as we work. Some of us are not satisfied with just snapping a picture. We want to improve and not just get by. In orthodontics, photography in all its forms has become most important, so our equipment keeps improving.

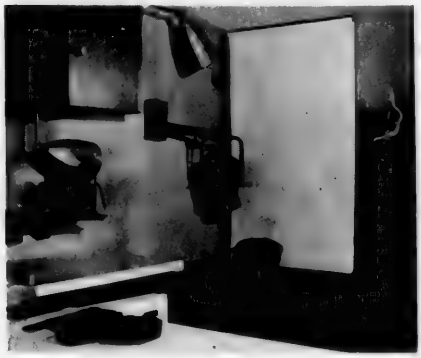


Figure 2.

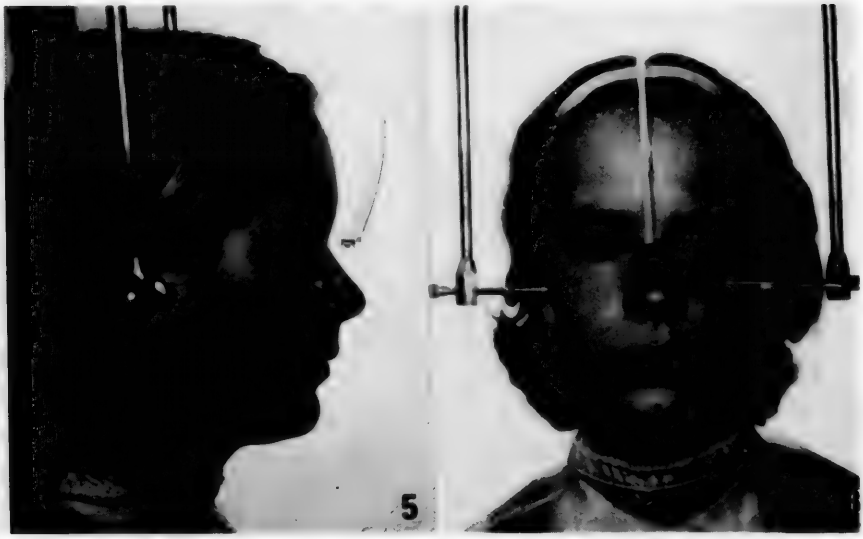
In 1947, I established my own photo unit (Figure 2). The head holder rotates. The center of rotation passes through soft tissue point nasion. Thus a 90-degree profile is obtained. The camera is focused and locked so that the image is of the standards in use. A contact print is made, eliminating enlarging process. It has a roll-back adapter for 120 film. The backdrop is a white window shade. Figures 3 to 8 illustrate a typical case study, obtained by comparing facial changes over several years. Photos and lateral cephalograms are often made here for prosthodontists and reconstruction specialists to help them in the diagnosis and analysis as well as the results of treatment.

As an orthodontist, seeking solutions for problems and answers to many questions in teaching, I consider research through and with photography a vital part of my dental practice. Now, I have complete facilities for the production of still and motion pictures, including copy and animation equipment (Figures 9 and 10), and editing, sound and projection equipment (Figure 11).

A good example of how still and motion picture photography aid in dental research and teaching is illustrated in Figures 12 and 13. In Figure 12, the typodont is in a closed position. A marker is at O. The face bow is supposed to push the last tooth (on the left) horizontally back, away from the other teeth. The forces comes from down below because the strap fits around the child's neck and is lower than the biting plane of the teeth. Figure 13 shows the end of the action where the tooth wants to go — in the direction of the source of pull.

Motion pictures are used to study these

Figures 3 and 4. Patient before treatment age 10 years, 3 months.



Figures 5 and 6. Same patient at completion of treatment at age 12 years, 8 months.

Figures 7 and 8. Follow-up of some patient eight years out of treatment, age 21 years, 2 months.

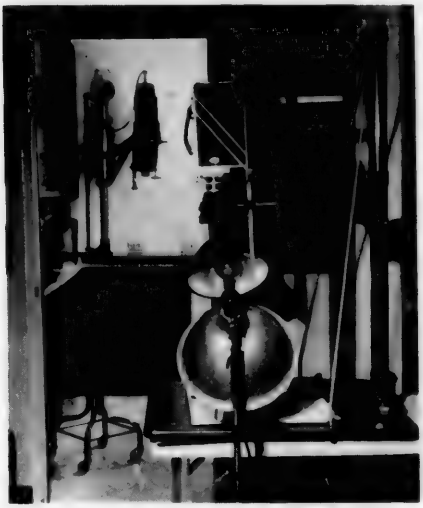


Figure 9.

changes in live action, from beginning to end, including slow motion, and to show the results of good orthodontics.

A few years ago in an accident case, plaster models were to be presented as evidence. As the models would be too small to be seen by the jury, they were photographed and enlargements were

Figure 10.

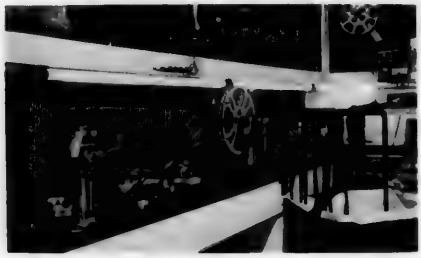


Figure 11.

made. The presiding judge held the models as the photos were explained. Fourteen views of all aspects were shown. The enlargements were 16 × 20 inches. As a result of good visual aids, the jury was able to see clearly the results of the accident on the individual teeth and the damage that would ensue to the patient's mouth. The case was decided in favor of the plaintiff.

I make all the slides I use for lectures. Photos of patients' models and X-ray plates are made in black and white. Pictures illustrating dental techniques, and live shots, are made in color.

For the last two years I have been using photography for condensation. When sent to distant places, but particularly to other countries, the bulk and weight of masks, models, or large cephalograms may become a serious problem of transportation cost, and trouble with customs.

When an orthodontic course is given, as many as 500 slides may easily be taken along. At least 20 treated cases with complete records of before treatment, during and after treatment and post treatment may be included. Most cases have 12 to 15 cephalograms and 4 to 5 sets of models and as many tracings.

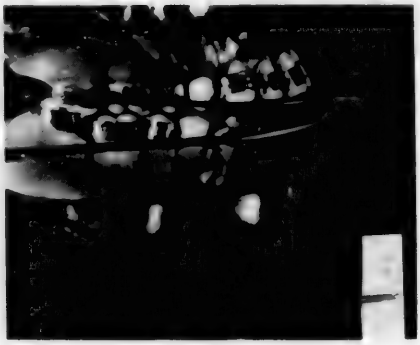


Figure 12.

Figure 13.

To make better use of limited storage facilities, I reduce all 8 × 10-inch cephalograms and tracings to 4 × 5-inch black-and-white transparencies. Photographs are reduced by being copied in groups on a 4 × 5-inch transparency. The 4 × 5-inch black-and-white transparency shows five views of each model. All are large enough to be viewed on an illuminator with the unaided eye.

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Delivered at the 38th Annual Meeting, Biological Photographic Association, Inc., Los Angeles, California, 12-15 August 1968.

NEW PRODUCTS

Information is that of the manufacturers. No endorsement by the author, his employer, or the Biological Photographic Association is intended.

Transparency Duplicators

A common photographic problem is that of duplicating color transparencies. Duplicating can add up to costly time and money, and much frustration. Determining exposure, color correction, and color balance are the main difficulties.

Through the years, homemade copy equipment has been constructed, but such setups are either extremely crude or very expensive. Building costs are high, and tests to establish an exposure guide are not only time-consuming but intricate. We therefore look to the photographic equipment manufacturer for slide-copy accessories and color-transparency duplicators.

A common camera accessory for color-transparency duplication is a movable bellows unit (Paillard Inc., Linden, N.J.; Minolta Corp., New York, N.Y.; Exakta Camera Co., Bronxville, N.Y.; E. Leitz Inc., New York, N.Y.; and others). The bellows is so designed that it can only be attached to a roll-film type of camera with a removable lens (Figure 1).

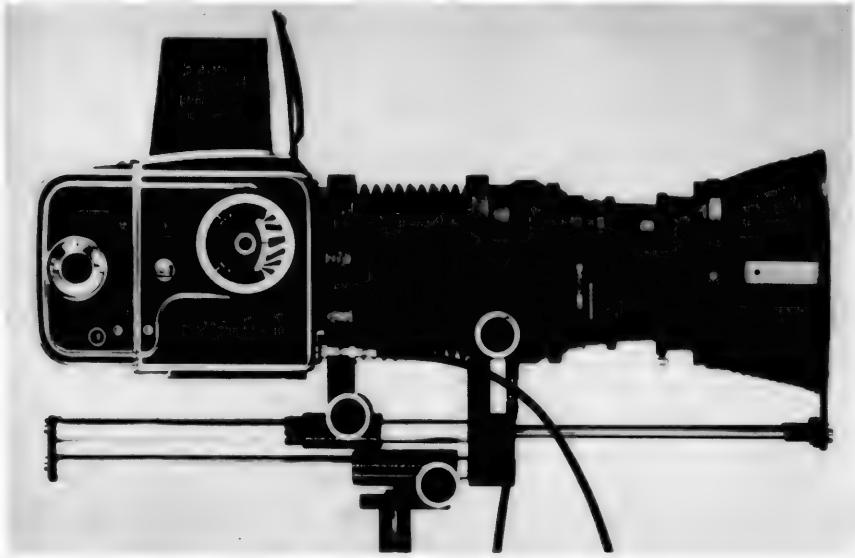

Figure 1. Bellows type of slide-copy accessory.

This accessory is excellent, and with it the determining of magnification is quite simple. For exposure, color correction, and color balance the bellows attachment is of little value because of the trial-and-error methods needed.

In 1964 Honeywell (Honeywell Inc., Denver, Colo.) introduced the Repronar 804 and a few years later the 805 (Figure 2). The Repronar is not only a practical slide duplicator, but a valuable tool for the creative photographer. Specialized creative color work can be accomplished quickly and easily without the need of a darkroom.

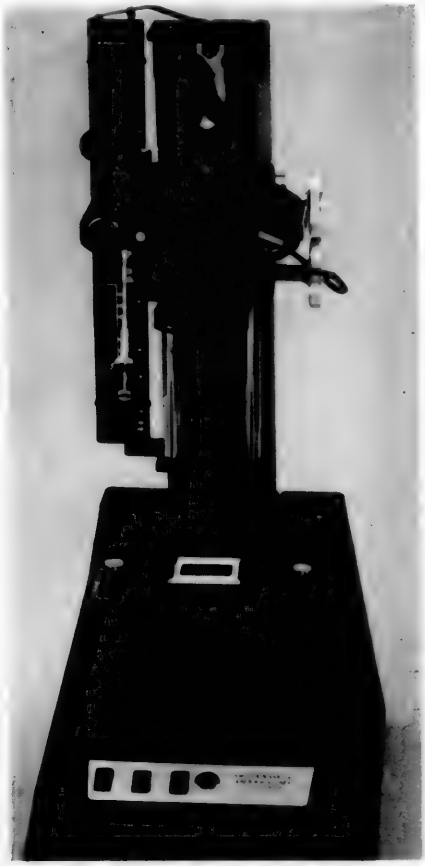

Figure 2. Honeywell Repronar 805.

The special 35-mm Pentax camera is a single-lens reflex type, with a high-quality $f/4$ Takumar preset lens designed specifically for the 805. The camera, with its rapid film-advance lever and film-rewind crank, is exceptionally easy to use. A selector button on the film-advance mechanism permits multiple exposures. A ground-glass screen lets the user see the image exactly as it will be photographed. Critical focusing is achieved with a magnifier, which flips over the eyepiece.

The working area, which holds the material to be copied, is an integral part of the Repronar base. The area has a flush-mounted opal-glass screen, approximately $3\frac{1}{4} \times 2\frac{1}{2}$ inches, through which the light from the electronic flash passes. In addition to the 35-mm slide holder, a $2\frac{1}{4} \times 2\frac{1}{4}$-inch holder is also supplied with the 805. A built-in filter holder beneath the easel accommodates standard gelatin filters for color correction or special effects.

The exposure calculator available on the 805 lends itself to a new and simple method of determining magnification and suggested f-stops for an average transparency. With the suggestion offered by this calculator the underexposed or overexposed off-color or poorly cropped slides can be saved.

The magnification range of the Repronar is $\frac{1}{2}$:1 to 4:1, which makes possible same-size duplicates from any 35-mm original, reduced duplicates from other sizes, up to and including $2\frac{1}{4} \times 2\frac{1}{4}$ inches, or cropped versions from portions of any slide. The 805 has two disadvantages that prevent it from becoming the best of the popular-priced slide duplicators: it limits the duplicate to a 35-

mm film, and full 3¼ × 4-inch lantern slides and 4 × 5-inch film cannot be reduced.

Last year, a moderately priced transparency duplicator (Figure 3) designed for this electronic age was introduced. It is manufactured in England (U.S. distributor: Bogen Photo Corp., Englewood, N.J.) and called the Illumitran.

The flexibility of the Illumitran, coupled with its constant color-temperature daylight-balanced light source, gives the creative photographer opportunities to devise new effects in his color presentations. Imagination is almost the only limit to the special effects that can be created. You can superimpose titles, add textures and vignettes to your original transparency, and create montages, double exposures, and multiple images. You can also diffuse the light to obtain soft-focus effects.

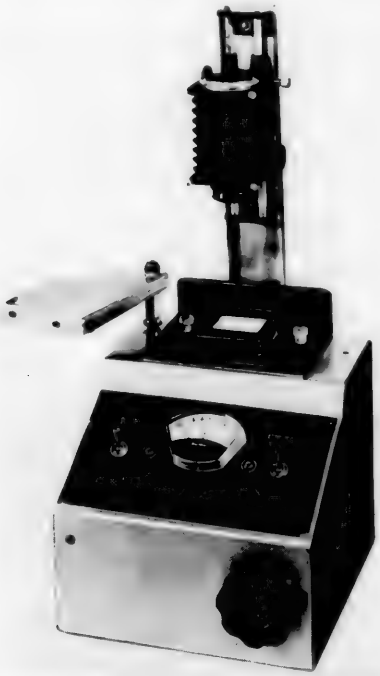

Figure 3. Bowens Illumitran.

The unitized construction of the Illumitran permits it to be adapted to a wide variety of applications. You can copy original transparencies as large as 4 × 5 inches. You can crop, enlarge sections of slides, correct for underexposure or overexposure, and make black-and-white positives from color originals. You use your own camera, regardless of size. A camera support and bellows is supplied for use with a 35-mm single-lens reflex camera. This 35-mm camera support and bellows is removed by loosening three knobs. A larger camera with its support unit can then be substituted. With this substitution you can copy larger originals 1:1 or enlarge your 35-mm 2¼ × 2¼-inch slides to 4 × 5 inches or larger. With a suitable single-frame camera, original transparencies can be copied to produce film strips.

The intense light output of the Illumitran and its unique filter holders give the user complete freedom in choice of films. Even the slowest copying emulsions can be used with reasonable lens openings. When high-speed films must be used for special effects, neutral-density filters can be inserted in the filter stage side without affecting the optical system.

The secret of Illumitran's variable-intensity control lies in its patented flash-tube stage, which, with two low-voltage tungsten modeling lamps, is mounted on a movable platform. These lamps are used for focusing. They are also the light source by which the plug-in meter cell reads the transmission density of the original to be copied. Since the tungsten lamps are in the same plane as the

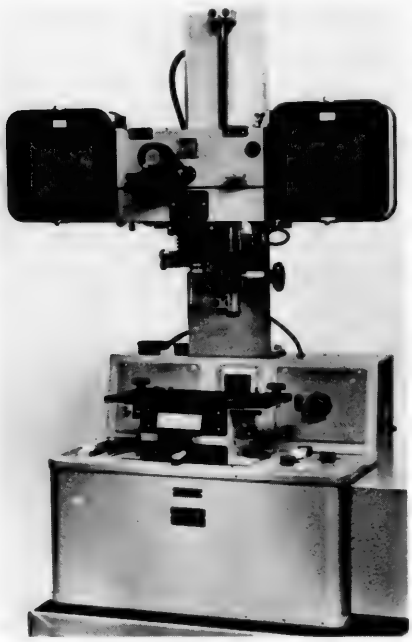

Figure 4. Emby-Homrich vertical optical printer.

flash tube and the same distance from the slide to be copied, both light sources follow the same square law of intensity for any of various positions. Adjustment of the intensity of the exposure is made by turning a large knob on the front panel of the Illumitran. This action moves the entire light stage up or down according to the required change shown by the meter. The simple but novel design enables the Illumitran to offer such a wide range of intensity variation that 90 percent of the duplicating requirements can be met without changing the lens aperture from its predetermined optimum setting. This procedure makes it possible to produce duplicates of similar density and good color from widely varying originals.

A person with unlimited funds who desires the ultimate in push-button electronics, can acquire an Emby-Homrich (Sickles Sales and Service Co., Scottsdale, Ariz.) verticle optical printer (Figure 4). Its capabilities are endless. By automatic control it duplicates slides, makes internegatives, prints slides, crops, enlarges, reduces, color corrects, and creates special effects.

Additional information on the color-transparency duplicators mentioned can be obtained from the manufacturers or their representatives.

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association services

Permanent Print Collection: A wide variety of prints on 16 × 20 mounts assembled from the Annual Print Exhibits of the BPA. Mixed or specialized subjects may be requested. Borrower pays return transportation. For booking write to: E. Lynn Baldwin, RBP, FBPA, Department of Medical Illustration, M. D. Anderson Memorial Hospital, Houston, Texas 77025.

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Members may propose for Fellowship in the BPA other members whom they consider worthy of recognition. To be eligible for Fellowship a candidate must have been a member of the Association for five consecutive years and must possess one or more of the following qualifications:

Superior craftsmanship in still or motion picture photography of biological subjects.
Ability in photographic research in new methods or materials.

The foregoing require submission of evidence.

Meritorious contributions to biological photography overall through sustained organizational work.

Two sponsors are required, one of whom must be a Fellow. The sponsors should be well acquainted with the candidate's work and ready to furnish the Board with details of his experience and achievements. Those who wish to sponsor a member whom they believe to be eligible should request a Fellowship Application form from the Secretary of the Fellowship Committee: E. Lynn Baldwin, RBP, FBPA, Department of Medical Illustration, M. D. Anderson Memorial Hospital, Houston, Texas 77025.

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The *Journal of the Biological Photographic Association* invites contributions, from members and nonmembers, of regular papers, brief articles, and short technical notes on methods, instrumentation, and applications of photography to health and the natural sciences. Topics may also include motion pictures, closed-circuit television, and other audio-visual aids, and research in the biological and related fields in which photography has played a major part. The editors reserve the right to reject manuscripts considered unsuitable.

There are no page charges. A reasonable number of black-and-white illustrations are usually accepted. The cost of plates for color illustrations, however, is required to be borne by the author or his employer or sponsor.

Material accepted for publication is subject to editorial revision. A manuscript needing extensive changes will be referred to the author or the senior author. Material is only accepted on the understanding that it has not been and will not be published elsewhere, except with the written agreement of the editor in chief.

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Submit the ribbon copy and the first carbon or a photocopy, typewritten on paper of good quality measuring 8½ by 11 inches, with margins of 1½ inches. Keep one copy. Double-space all parts of the manuscript. Underline only words that are to be set in italics. Number each sheet in the upper right corner. Do not staple sheets.

Wherever possible, avoid footnotes by incorporating information in the text. Use abbreviations sparingly, except for standard abbreviations common to photography and biology. For spellings consult *Webster's Third New International Dictionary*.

Arrange the copy in the following order. On the first sheet enter title of article, name of author with at least one given name, author's mailing address, and title for running head. Continue with the main text; acknowledgments, including a note of grant-in-aid; references or bibliography; tables; cutlines for illustrations; and illustrations.

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VOLUME 37 NUMBER 2 APRIL 1969

JOURNAL OF THE

biological photographic association

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Cover Photograph

"Specimen Block," by E. Lynn Baldwin of Houston, Texas. This picture received First Award (General Illustrative Category, Monochrome Prints) at the 38th Annual Meeting of the BPA.

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Lardner A. Coffey, RBP, FBPA
General Chairman, 39th Annual Meeting
Section of Photography, Mayo Clinic
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THE BIOLOGICAL PHOTOGRAPHIC ASSOCIATION, INC.

The Association is an international professional organization of scientific photographers and other communications specialists who work in the natural and health sciences. Persons interested in scientific photography, but whose vocational status does not qualify them for active membership, may join the Association as affiliate members.

The B.P.A. was founded at Yale University, in 1931, by a group of scientific photographers, to provide a forum for the dissemination of information on methods, techniques, materials, and instrumentation as applied to scientific research and teaching. The B.P.A. has now over 20 chapters in the United States, Canada and India, with over 1000 members. There are also numerous members-at-large in many countries throughout the world.

Three classifications of membership are available: active, affiliate and sustaining. In recognition of professional excellence, award plaques and certificates are conferred annually for the best scientific paper published in this journal and presented at the annual meeting, and for outstanding contributions to still and motion pictures and TV tape exhibits. Fellowship in the B.P.A. is conferred for significant achievements and meritorious contributions to the advancement of photography in the biological sciences.

Annual meetings are held every autumn for the purpose of presentation of scientific programs of papers, workshops, scientific and commercial exhibits, and refresher courses. Regional and chapter meetings are also held.

The B.P.A. publishes this journal and the Newsletter, which informs members about chapter activities, personal information, and employment opportunities for scientific photographers.

The B.P.A. has established and maintains a Board of Registry for the purpose of examining and certifying qualified scientific photographers. The aim of this certification program is to raise standards and provide criteria for those interested in employing qualified scientific photographers. This program has been established in consultation with the United States and Canadian medical associations, hospital associations, dental associations, the American Institute of Biological Sciences, and several other influential professional societies.

Further information about the B.P.A. may be obtained from Mr. R. M. Christopher, Executive Secretary, P.O. Box 12866, Philadelphia, Pa., U.S.A. 18108.

Inquiries regarding the Certification Program are to be addressed to the Secretary of the Board of Registry, Mr. Will E. Renner, Medical Illustration Service, School of Medicine, University of California, Davis, Calif., U.S.A. 95616.

in black and white

One reason why scientific photography does not always enjoy the recognition it deserves is the opinion developed by advertisers that everybody can take pictures. No doubt, modern cameras and improved photographic materials have considerably simplified the process of taking snapshots, and mass production or import of inexpensive equipment has brought this fascinating pastime within the means of all adults, most teenagers, and even many children. Indeed, taking snapshots is now not more difficult than making toast in an automatic toaster. The bread is inserted into the toaster, a lever is pushed, and in a few seconds golden-brown toast pops up; the film is inserted into the camera, a button is pushed, and in a few seconds a snapshot is finished. Unfortunately, this simplification and the resulting popularity that photography enjoys nowadays are greatly responsible for the misconception that regardless of application or involvement it is all "just photography" and, consequently, there cannot be very much to it.

Most scientific photographers are employees of research and educational institutions; they do not sell a product but provide a service. Administrators of such institutions are often amateur photographers, and it is, therefore, not surprising that in their opinion photography is an extremely simple matter. They are often tempted to hire individuals with inadequate or doubtful qualifications at much lower salaries than they would have to pay fully qualified scientific photographers. This economy is entirely false. The savings in salaries are not nearly enough to offset the waste in man-hours and materials caused by incompetence, and the results are substandard services. On the other hand, scientists who use our services can much better appreciate the value of high-quality professional photography, and they are often at odds with administrators when qualifications and salaries of prospective employees are discussed.

It is also not always fully understood that photography in the sciences is so different from general photography that an experienced portrait or commercial photographer requires a thorough retraining to become a scientific photographer. The main difference is basic. For the portrait or commercial man, photography is a form of art; for the scientific photographer it is a science. This basic difference molds the photographer's way of thinking and governs his approach to a problem.

In practice, the portrait or commercial man uses all his knowledge and imagination to make women look beautiful, to reflect the strength of character in portraits of men, or to bring out the most appealing features in a commercial product. To obtain these results, he uses all the tricks of the trade, regardless of how artificial, though pleasing, the created image may be.

A scientific photographer, on the other hand, goes to a great deal of trouble and uses all his knowledge and skill to obtain a realistic image, with all detail in correct perspective, whether or not the photograph supports or contradicts the hypothesis it is supposed to prove. To be able to anticipate what will happen under specific conditions, and thus avoid excessive aberrations, poor color rendition, and many other possible artifacts, the scientific photographer must have good knowledge of underlying principles, particularly optical physics and photographic chemistry. Since photographic results may be affected by many factors and conditions, it is important in scientific photography to standardize all techniques and to keep accurate records of all technical data; otherwise, the results may be influenced by different factors each time an exposure is made, and no valid comparison and analysis may be possible. Without comprehensive records it may be very difficult to trace the source of any trouble, or to identify the material.

On-the-job training is no longer adequate. The knowledge and skills demanded of scientific photographers must be acquired through formal professional education at a polytechnical institute or a university and a period of practical internship. Regular diploma or degree courses in scientific communications are therefore more important for the scientific photographer than courses in general photography are for the portrait or commercial man.

The Biological Photographic Association welcomes the news that the Rochester Institute of Technology has established a unique two-year course in biomedical photography that leads to an associate of science degree and is designed to prepare graduates for a photographic career in the life sciences. Students graduating from this two-year program may continue their studies at RIT, in the School of Photographic Arts and Sciences, to obtain a bachelor of science degree.

For the benefit of those who are already professionally engaged in scientific photography and cannot take time off for full-time studies, the BPA offers refresher or workshop courses in several subjects related to photography in the natural and health sciences. These courses are usually offered as a week-long program immediately preceding the annual meeting.

Because the increase of professional knowledge and skills results in more effective and efficient services provided by the photographer, the employee and the employer should take full advantage of every opportunity to further professional education. It is not unreasonable to expect promising employees to be given time and some financial support to participate in the educational programs offered by the BPA

or to benefit from the scientific programs of annual meetings. But employees should also be prepared to use some of their own means to further their professional knowledge, and not make the participation in educational programs and scientific meetings solely dependent on the support of employers. Too often photographers spend much time discussing inadequate salaries and make too little effort to justify higher salaries through an increase of knowledge and skills and, consequently, through better and more efficient services.

With this issue, we introduce a new cover design. Among its practical and artistic values is provision for the reproduction of one large photograph in either horizontal or vertical position. Although the previous cover design had its own charm, it presented photographs solely as motif. The editors felt that our readers needed the opportunity to have their work reproduced on the cover of their journal, and that the picture had to be large enough to show adequately the scientific information and the esthetic beauty contained in the original photograph. The cover was designed by Mrs. Mary Brett, Design Artist, Canada Department of Agriculture, Ottawa.

Stanley Klosevych

announcement

DEGREE COURSES IN SCIENTIFIC PHOTOGRAPHY

The Rochester Institute of Technology announces the establishment of a two-year course in biomedical photography leading to the Associate of Applied Sciences degree. The program is designed to prepare graduates for a photographic career in the life sciences.

The first students will be admitted to the program in September 1969. During the first year they will be required to study basic photography, photographic materials and processes, mathematics, language and thought, and cellular, animal, and human biology. A summer internship in a medical or biological communications facility will follow. The second-year program will include biomedical photography, design and preparation of biomedical visuals, color photography, and general studies, and a second summer of photographic internship.

Those who wish to obtain a bachelor of science degree will have to continue their studies for two more years at RIT's School of Photographic Arts and Sciences, Department of Professional Photography.

The BPA is cooperating with RIT in setting up the program. The program director is Mr. John F. Trauger. Further information regarding this course may be obtained from the School of Photographic Arts and Sciences, Rochester Institute of Technology, 1 Lomb Memorial Drive, Rochester, N. Y., U. S. A. 14623.

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Managing your photographic department

ROBERT R. ARMSTRONG

A management device or technique, regardless of the degree of sophistication, is only a tool and can never be a substitute for effective managers. The tool or technique must be an integral part of the entire management process. Logically, therefore, in the presentation of a management technique such as work planning and control, a sound concept of the management process must first be established.

The management process has evolved through many years of trial and error. Much has been written about the function, environment, and role of management. Very little has been done to develop and describe an orderly process by which good managers can go about getting things done. Therefore, I propose to develop the management process concept, including identification of the relationship between the management process and the techniques of work planning and control.

The function of management entails the continuous, intelligent direction of others by determining and communicating the prime and supporting objectives of an organization. This function necessarily includes the development and utilization of an integrated time-phased plan of action, demanding reasonable requirements in the way of resources and the subsequent balancing of resources as they are made available and used.

I will emphasize the distinct form of the cycle of applied effort. The basic steps of the management process are the following:

- The determination and effective communication of the prime and supporting objectives
- The development of a coordinated plan of action for the accomplishment of the objectives
- The conversion of the plan into integrated schedules within allocable resources
- The regular reporting and concurrent evaluation of progress against the scheduled plan and cost estimates
- The recycling of the above process to achieve the incorporation of a desired new action into a new cohesive scheduled plan.

Establish objectives

The determination and definition of objectives is the first and most important step in the management process, largely because the objectives of an organization

ABOUT THE AUTHOR

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are its sole reasons for existence. All organized activity must have as its motivating and guiding force the attainment of some predetermined objective or objectives. The current purpose or purposes of the organization must be the yardstick against which all requirements and accomplishments are measured and evaluated. The progressive passing down of specific coordinated objectives from higher to lower levels of management sets the target for and the authorization of detailed planning effort on the part of the receiving organization.

The importance of the effective communication of concise planning objectives from level to level of responsible management cannot be overemphasized.

Develop plans

Given the determination or assignment of an objective, the next step is the development of a plan. The planning function sets forth the nature, sequence, and interrelationships of the supporting objectives that must be accomplished to achieve the main objective. Planning is primarily concerned with the structuring and relationships of units of required effort. It establishes the feasibility of meeting the directed due date for the successful attainment of the objective.

This plan must be realistic in its requirements and consistent with the available resources and time. The planning function at each level sets forth the important objectives of kind, quality, and quantity for the work to be performed. If this planning is not accomplished, there can be no assurance of a coordinated, balanced use of resources. Initial planning considers the required resources, including elapsed time.

Determine schedules

Scheduling is the bridge from the planning stage to coordinated, effective implementation. It is the translation of the plan, with its elapsed time estimates, into calendar time. The scheduling function considers the competition for available resources both within and between the various programs. If the earliest attainable scheduled completion date of the current plan is later than the desired date, the manager will plan for readjustment. If he cannot achieve this, he must determine a new completion date.

The goal of the scheduling function is to produce a calendar time-phased plan consistent with desired completion dates for the assigned objectives. This schedule is the vehicle for authorizing effort and resources to be expended. It serves as a basis for the continuous evaluation of progress.

Progress evaluation

Once the scheduled plan has been activated, a formal procedure for the regular reporting of progress against the scheduled plan is necessary. This procedure necessitates a process for the early detection and specific description of a potentially significant problem area while there is still time for management to seek solutions to that problem. The management process emphasizes, therefore, regular, continuous evaluation of actual performance against current scheduled plans, and detection and isolation of significant deviations from the scheduled plan as a forecast of time and cost overrun.

The principle of "significant reporting" effects a great reduction in the volume of statistical reports. By considering only the significant deviations from the scheduled plan, the manager need

only obtain a detailed analysis of the specific problem, which covers what remedial action is being taken and by whom, and what results may be expected and when.

Management decisions and actions

The magnitude and relationships of all desired changes must first be examined in the light of their effect on the scheduled plan. Changes may result from alteration in prime objectives or isolation of the problems at any level of effort. The point of origin of the changes is not so important as the orderly method of authoritative approval and implementation.

Deviations from the scheduled plan may require only a change in schedule. Deviation could, however, require a change in plans, or even a change in objectives. By concentrating on the most important current or forecasted problems, management can expend its efforts to achieve the maximum potential returns pertinent to the assigned objectives.

A clear distinction must be made between new action that is within the authority of the operating organization and action that calls for lateral or higher authority. The first can be handled by direction; the second calls for a careful presentation of the facts and a request for the action desired.

Recycle

Change is achieved by a recycling of the management process to provide a revised scheduled plan. Dynamic recycling is the method of achieving and maintaining management control of objective-oriented effort. The formal progress, reviews, and evaluation meetings held by department heads with their subunit chiefs provide an opportunity to accomplish the mechanics of the recycling process.

Principles of work planning and control

Any principles, no matter what they may be, will always be subject to criticism. The possibility of such criticism, however, should not prevent us from making a concerted effort to develop these principles.

The six principles that have been developed here are not intended to be all-inclusive, but are presented to stimulate discussion. The purpose of such a discussion is to provide a means for checking the value of a work planning and control system.

First, the flow of information should be considered. The scheduling group in an organization is dependent upon information furnished to it from many sources. Such information as the work to be done, the method by which it should be performed, the resources to be utilized, and how long the work should take must be available before the work can be properly scheduled and started. If any of this information required for planning is not forthcoming or complete in proper detail, the resultant schedule will be unrealistic.

This is only the beginning, however, for communication of facts regarding the progress and completion of work is the life breath of work planning and control. Delays in receipt or omission of pertinent facts will greatly diminish the potential of corrective action. This information must also be accurate. The more controlled variables in a work situation the more accurate the data upon which the plan is based. The degree of predictability determines the tightness of control. The work may be tightly controlled to the individual piece, as is done in large-volume production runs, where machine times, operation times, and handling times are closely calculated. Careful attention must be given to the

receipt, amount, and degree of information available and needed. The first principle, therefore, is that any system of sound work planning and control must furnish timely, adequate, and accurate information.

The system must be flexible enough to accommodate necessary changes. Many plans are designed with the probability of change in mind. The changing demands placed on any organization are the cause of frequent revisions of plan. Such demands must be accommodated. If the demand is not met, there is the possibility that there will be fewer demands in the future and less work to be done. Attempts made to "squeeze it in" or speed up operations so that the plan need not be changed are generally unsuccessful. Thus, the second principle may be stated as any system of sound work planning flexible enough to accommodate necessary changes.

The system must be simple in operation and understandable by all employees concerned. You have, I am sure, walked into an office and seen hanging on the wall a control board on which is a maze of colored pegs, strings, or lines. A single glance would not suffice to explain the status of the activity, and an involved lecture by the people using the control board would seldom make the system understandable. You may have wondered whether the users of the system clearly understand the system themselves. Such systems may be too complex and contain too much information, and the users may be trying to control too many things at one time. It is possible that such a system may result in costly errors. Thus, the third principle is that any system of sound work planning and control must be simple in operation and understandable to all employees concerned.

The system must be economical. Modern concerns selling control systems are all too prone to install as expensive and complex a system as they can sell. It is foolish to buy more system than is needed, since the upkeep is costly and effort to maintain the system is endless. On the other hand, too little system often results in having to perform the planning and control functions to the detriment of more important duties, usually resulting in a lack of accurate control information in an organized form. This "hidden cost" of not enough system is reflected in low effectiveness and a high overall operating expense. Thus, it can be seen that there are evils in both too much system and too little system, and the right solution is the use of the most economical system that will do the job. Hence comes the fourth principle, that any system of sound work planning and control must be economical in operation.

The system must require prior planning by the user. Scheduling has been defined as determining the time to start a product into production or to begin an activity. Determining at 8:55 in the morning what is to be done by 9:00 AM is not considered proper scheduling, since the planning did not take place long enough in advance. It can be seen that any system that permits a normal run of production to be determined just prior to the carrying out of that activity is not properly functioning in planning and control.

A proper system ensures that its users sit down at some preset time before operations are to begin, and, using all available past information plus forecasts based on changing conditions, they schedule or time-phase the elements of the facility being planned.

The system must ensure that these decisions are made well in advance of performance. This does not say that changes will not be made, but only that there is something to change from, some basic level of planning knowledge on which to build. Since all schedules are "hope-we-cans," it is no crime to miss a schedule, but, as a group continues to schedule, their ability to take into account changing conditions increases tremendously. Thus, any good system of work planning and control must ensure prior planning.

The system must permit "management by exception." As a complex organization operates, reams of data concerning the status of work in production flow in. If a planning and control system were to attempt to treat each item of a report in the same manner, it would soon be buried in a mass of trivial considerations. In order to alleviate this situation, a sound work planning and control system must permit only those situations that are out of control or behind schedule to be brought up for corrective action. For example, the Gantt chart, which visually depicts the single item that is far behind schedule (by lagging to the left of the "today" line of balance) is a good example of permitting management by exception. The users of such a chart need take action only on the item that is behind schedule, and may forget about all the other items. In other words, if something is wrong, the system must flash only that information to the user. And if things are going smoothly, no such data should come to anyone's attention. Management can operate most effectively only when the system permits management by exception.

Management tools and techniques

I have tried to emphasize the importance of planning, because it is a dynamic element of the management process. Here are some of the tools and techniques.

Organizational and functional charts are necessary to portray graphically the formal structure and authority relationships. The functional chart specifically describes the role of each organizational component, and normally enumerates those relationships not shown on the formal organization chart. This functional chart, in addition to the organizational chart mentioned previously, is also used for staffing and budgetary purposes.

Some attempt must be made to develop criteria to measure productivity and provide a basis for scheduling work. In other words, standards should be developed to show the average time required to perform one unit of the various categories of work performed in your areas. For planning purposes, such gross data as the total number of negatives, color prints, prints, drawings and paintings, charts and drafts, the motion picture footage, hours of sound recordings, and other items are recorded. Standards, manpower utilization, and cost of operation can be derived from this gross data. For example, the following steps will lead to a rough standard of the time needed for the performance of a function in your areas.

First, use work distribution charting to determine the percentage of time devoted to the various categories of work for a given period. Concurrently, ascertain the number of items produced in each category during that same period.

Next, convert the percentages of time into actual minutes or hours. For example, if in a 160-hour period 25% of the time is devoted to drawings, charts, and graphs, then 160 multiplied by .25 or 40 hours is spent on this category of work.

Thirdly, divide the number of drawings, charts, and graphs into 40 hours to get the average time to produce one item. For example, if the number of charts is 32, then the average time is 40 hours divided by 32 or 1¼ hours per item.

Lastly, this average time can be refined further by subtracting 5% for personal time and 11-13% for vacation and sick-leave time. This will leave the two fundamental components of any task, the basic time or actual time required to do the job, and allowance time or that time required for preparation or get-ready and put-away or clean-up.

The foregoing is a rough standard, and it is quite essential in scheduling work and determining manpower needs. It is an oversimplification of the development of a standard, but it will provide you with an unscientific yet handy and useful management tool. Also, this simple tool can be devised without a great amount of orientation and training in work simplification.

In view of the increased attention to cost reduction and economy of operation in hospitals, the maintenance of comparative data to reflect trends is a necessity. Charts depicting the following items are suggested.

Actual versus planned cost of operation

Actual versus planned full-time equivalent staffing

Actual versus planned expense for film and other supplies needed for the operation

The cost of operation per man-hour
Direct cost per bed

Actual versus planned income, if any

Comparisons, by report period, showing motion picture footage, hours of sound recording, number of drawings, paintings, charts and drafts, and the number of negatives, prints (black-and-white and color), color transparencies, and other items.

Summary

Success as a manager demands ability to decide in advance what to do, how to do it, when to do it, and who is to do it. There is no substitute for the planned approach in managing any organization. You will note that I have not emphasized any specific organization or function, because the principles of management are universally applicable.

The overall goal of any organization is to survive, and survival is dependent on success. Success is not measured entirely on profits. Concomitant criteria include the goal of achieving optimal return from the employment of people and the efficient use of resources available to accomplish the job. Also essential is the achievement of increasing productivity at decreasing unit cost and development of a stable and loyal work force.

Lastly, you must accept the fact that change is inevitable. There is no place for the status quo in this age of rapid changes and advances in technology and managerial philosophy. This situation has dictated the need for the application of sound management techniques and the continuous systematic review of

operations. Remember, the management process is cyclic and the search for new methods and ways to make your organization more efficient is never-ending. The survival of those organizations that are not concerned with the principles mentioned is in jeopardy. However, the acceptance and the application of these principles is excellent insurance for success and survival.

Delivered at the 38th Annual Meeting, Biological Photographic Association, Inc., Los Angeles, Calif., 12-15 August 1968.

WORKSHOP COURSES IN SCIENTIFIC PHOTOGRAPHY

The Biological Photographic Association will offer courses in scientific photography preceding the 39th Annual Meeting, in Rochester, Minnesota, in August 1969. Tentatively scheduled for presentation this year are the following subjects:

Principles of Professional Scientific Photography
Patient Photography (Medical)
Small-object Photography (Photomacrography)
Photomicrography
Motion Pictures for Science
Closed-circuit Television
Management of Scientific Communication Establishments

These courses, established in 1965, are designed for practicing scientific photographers who wish to further their professional knowledge and thus provide more valuable services. It is in the interest of the employee and the employer to facilitate participation in these courses by staffs of scientific communication establishments. This year, newcomers to scientific photography, as well as established biophotographers interested in a refresher course, will, for the first time, have an opportunity to attend lectures and demonstrations in basic methods and simple instrumentation. For the experienced photographer, courses in advanced techniques will be offered; and for administrators of scientific communication departments, a special course in management is planned.

In the past, these courses were very popular, and it is expected that again this year for some of these courses the subscription limit will be reached within a few weeks after the official announcement. The final agenda will be announced in the next issue of this journal, and members will receive registration forms. B.P.A. membership is not obligatory for participation in these courses. Those who are not on the regular mailing list may obtain registration forms and pertinent information by writing to the course coordinator:

Percy W. Brooks, RBP, FBPA
Cornell University Medical College
1300 York Avenue, Room A-162
New York, N.Y., U.S.A. 10021

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A stereophotogrammetric microscope

TADASHI UENO

Stereophotogrammetry has been developed for constructing topographic maps from pairs of aerial photographs. Recently, it has also been used for three-dimension measurements in the field of engineering. In both cases, the specimens for stereophotogrammetry have been limited to the "macroworld." This method has now been transferred to the "microworld," and an experimental microscope that enables the plotting of contour lines on cells has been built.

The general appearance of the microscope apparatus is shown in Figure 1. A pair of stereophotograms of Golgi-stained nerve cells taken with this equipment was placed under a stereoplotter so that contour lines could be drawn (Figure 2). The stereoplotter is described in the following section. The cells most suitable for microstereophotogrammetry are about $10\mu \times 10\mu \times 10\mu$. With this apparatus, it is possible to plot contour lines at intervals of 2 to 3μ.

Stereophotography

Microstereophotogrammetry requires a pair of photomicrographs of the same specimen taken with two objectives separated by a definite distance (Figure 3). When the paired photomicrographs are viewed with a sterescope they are seen as a stereoscopic image. For three-dimension measurements, with the aid of a stereoscopic plotting machine, contour lines are plotted while this image is being observed. A longer objective separation produces a more pronounced relief effect and consequently a more accurate depth measurement. In addition, when the axes of the objective pair are parallel, for so-called parallel stereophotomicrography, the photos do not

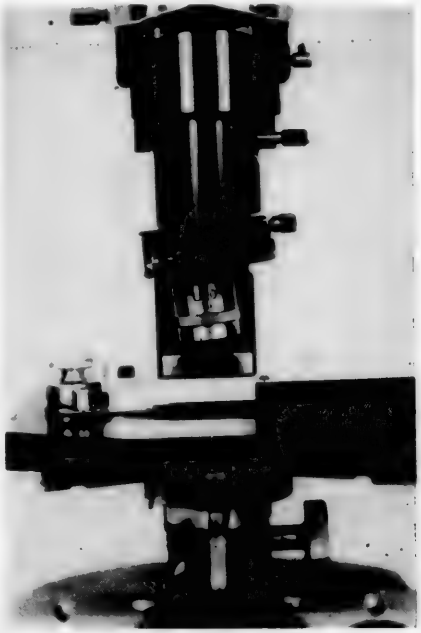

Figure 1 Microscope apparatus, showing objective in tilted position.

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Tadashi Ueno is General Manager and Chief Designer of the Microscope Division of Nippon Kogaku K. K., Tokyo, Japan.

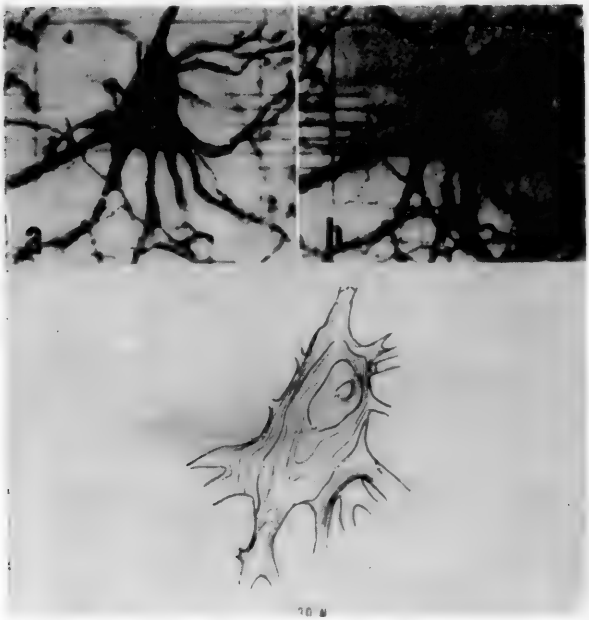

Figure 2 Stereophotograms (*a*, *b*) of motor neuron in the cervical cord of a cat. From this pair the contour line plot *(below)* has been drawn. The contour line interval is 2.5 μ.

have perspective distortion, and a simple stereoscopic machine suffices for plotting contour lines.

For parallel-objective stereophotomicrography under an ordinary microscope, two photos are taken, the second after the position of the stage is shifted horizontally (Figure 3, *left*). However, the field of view of the microscope objective is rather small, and when the base length (Figure 3, *b*) is made larger, the specimen cannot be converted into a properly oriented pair of photomicrographs. For example, with 35-mm equipment and a 60% overlap in the stereophotomicrographs, a ×10 objective should be employed. The maximum allowable horizontal stage shift is 0.3 mm, which results in less accurate depth measurement.

Taking these facts into consideration, we decided to adopt a convergent system by tilting the optical axis of the microscope as is done in a stereoscopic microscope. A combined reflecting mirror and tilted microscope objective is rotated 180° around the axis H – H′ (Figure 3, *right*), and used to take a stereo pair of photomicrographs. With our equipment, stereophotomicrographs with a 100% overlapped field are obtainable, and, as the base length becomes longer, a better relief effect is obtained. In the aforementioned example, that is, with 35-mm photomicrographic equipment and ×10 microscope objective, photography with a 6° inclination on either side of the optical axis creates more than a 3-mm base length,

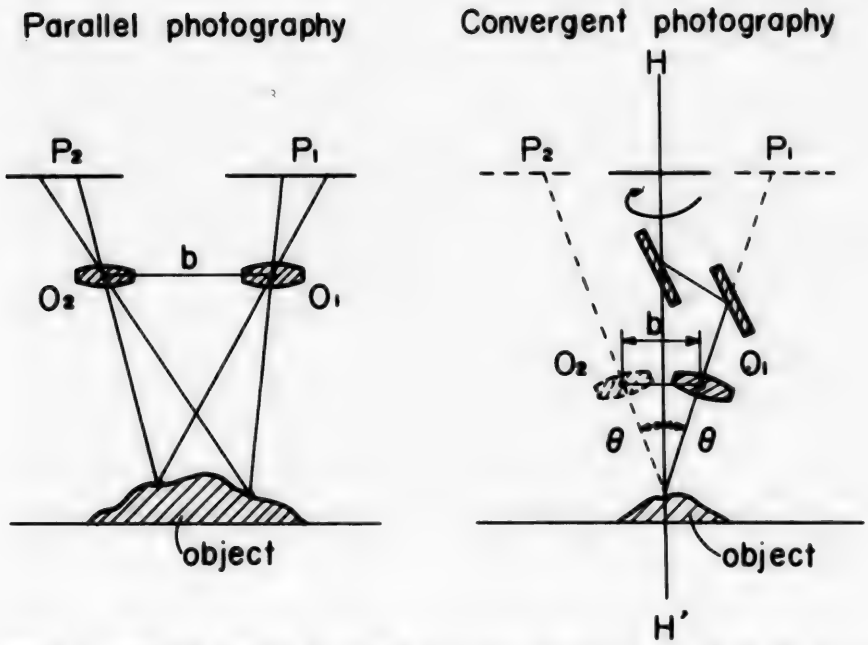

Figure 3 Objective positions for parallel and convergent photography. P_1 P_2, film plane; O_1 O_2, objectives; θ, 6° inclination; *b*, base length; *H*-*H'*, optical axis.

and more than ten times a depth accuracy can be obtained with the tilted objective than with parallel objectives. However, such oblique photographs possess more perspective distortion, which causes positional misconceptions that result in distance errors in the X–Y plane.

Furthermore, two photos combined for stereophotogrammetry create errors in depth, that is, in the Z-direction measurements. To avoid these errors, a stereoplotting machine costing more than $10,000 might have to be used. Fortunately, in photomicrography, since the field of view of an inclined microscope objective does not exceed a few degrees of arc, which is rather small compared with the 90° field coverage of the wide-angle lenses used in aerial photogrammetry, the perspective distortion can be disregarded. With a 6° inclination, the perspective distortion in the image plane of 35-mm film is about 0.3μ, which is less than the resolving power of the objective and can safely be ignored. Therefore, the results can be treated in the same way as those produced by parallel objectives. For this reason, a stereoplotter made by combining a relatively inexpensive stereoscope and stereomicrometer serves the purpose very well. An experimental model was constructed with plotting device attached (Figure 4). The only serious fault in oblique photomicrography is that the periphery of the print in the direction of inclination goes out of focus. For better results, the shorter frame line of the 35-mm film should be oriented in the direction of inclination, that is, the east–west direction.

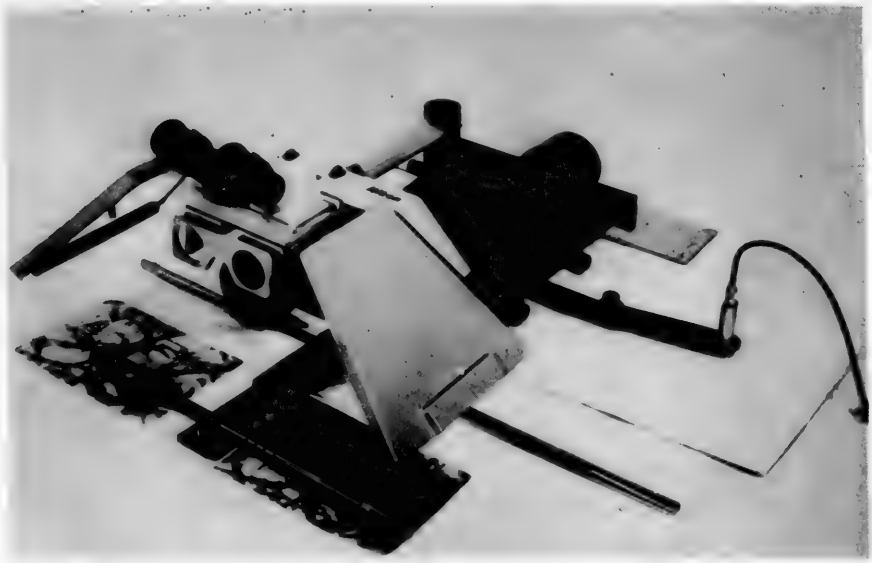

Figure 4 General appearance of stereoplotter.

Recording the points for absolute measurement

In aerial photogrammetry, it is necessary to include in the photos some areas in which the X, Y, and Z values are shown for absolute three-dimension measurements. The same requirement is needed in microstereophotogrammetry. This is especially so because 35-mm photos should be enlarged for measurement under a stereoscope, and in enlargement it is quite difficult to maintain sufficient accuracy. Therefore, a few standard points of reference in the prints are needed. They should serve as standard points for plane location, X and Y, and depth, Z. For this purpose, in the substage there is provided an optical-scale projection system, which focuses a linear-scale image in the specimen plane (Figure 5, *left*). One increment of the scale corresponds to a length of 10μ. With this value and corresponding scale interval appearing on the enlarged pair

Figure 5 Optical scale patterns: *left*, linear scale; *right*, depth scale.

Figure 6 Images of scale projected onto the specimen as viewed through the rotatable tilting objective. The dots are on the right or left, according to the inclination of the objective.

of prints, a compensated value in the X–Y plane can be calculated. For the depth standard, as shown at the right in Figure 5, images of two dots are focused 15μ above the linear scale. The dots are slightly displaced to the side of the center line (Figure 6). The degree of displacement, that is, the degree of parallax, is measured by means of a stereomicrometer on the pair of enlarged prints. The figure corresponding to the known absolute values gives the compensated value of depth. On a specimen the scale and dots can be overlapped to appear as bright or dark images. The optical scale projection system is illustrated in Figure 7. It should be added that it is possible to picture the scale simultaneously with or independently of the specimen.

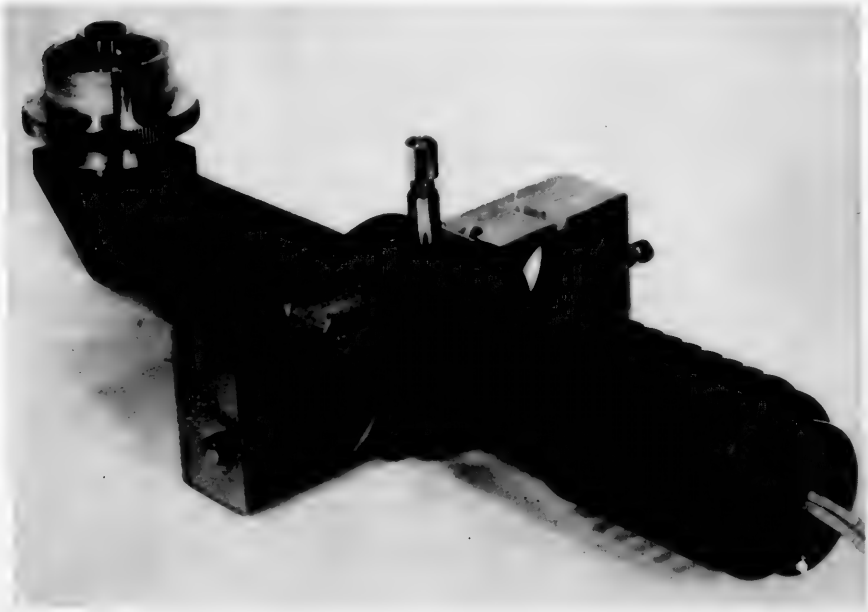

Figure 7 Optical scale projection system.

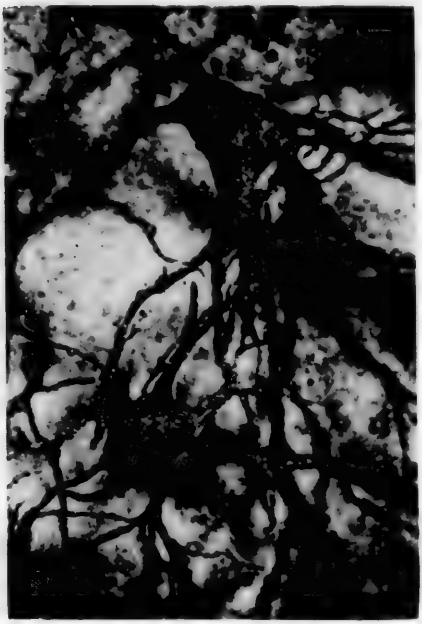

Figure 8 Photomicrograph taken with combined oblique and transmitted light.

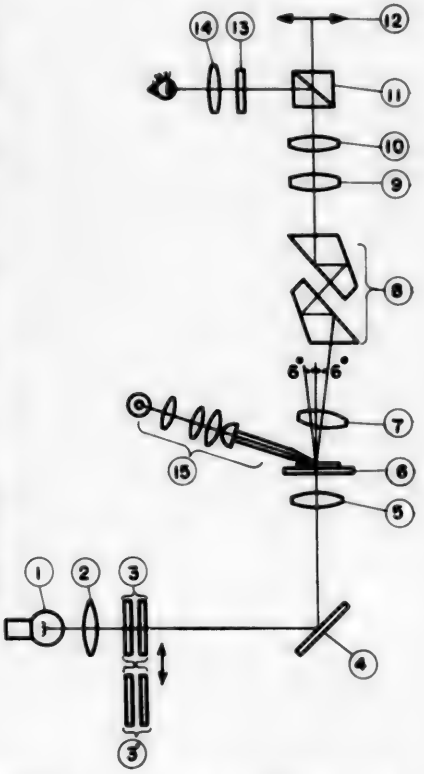

Figure 9 Diagram of optical system of stereophotogrammetric microscope. Numerals: *1*, light source (6-volt, 15-watt tungsten bulb); *2*, collector lens; *3*, graticule for dark dots and scale; *3'*, graticule for brighter dots and scale; *4*, mirror; *5*, condenser lens; *6*, specimen; *7*, inclined objective (rotatable 180°); *8*, binocular tube prism; *9*, eyepiece; *10-14*, components of Nikon Microflex photomicrographic attachment; *15*, oblique illuminator.

Oblique illumination

To obtain a stereoscopic image from a pair of stereophotographs, the surface of the specimen should be made to appear bright and crisply sharp. Moreover, since the accompanying shadows impart vividness to the picture, it is advisable to use oblique illumination.

In this work, a glass rod about 5 mm in diameter, with one end tapered, is used as a light guide, as in fiber optics, to illuminate the specimen obliquely. As light source, a 200-watt Xenon flash is used with a condenser lens. It concentrates the light flux on the end surface of the glass rod to provide optimum intensity of illumination.

Depending on the characteristics of the specimen, it is sometimes advisable to combine diascopic, or transmitted, light with oblique light, as was done in taking Figure 8.

The optical system of the stereophotogrammetric microscope is diagramed in Figure 9.

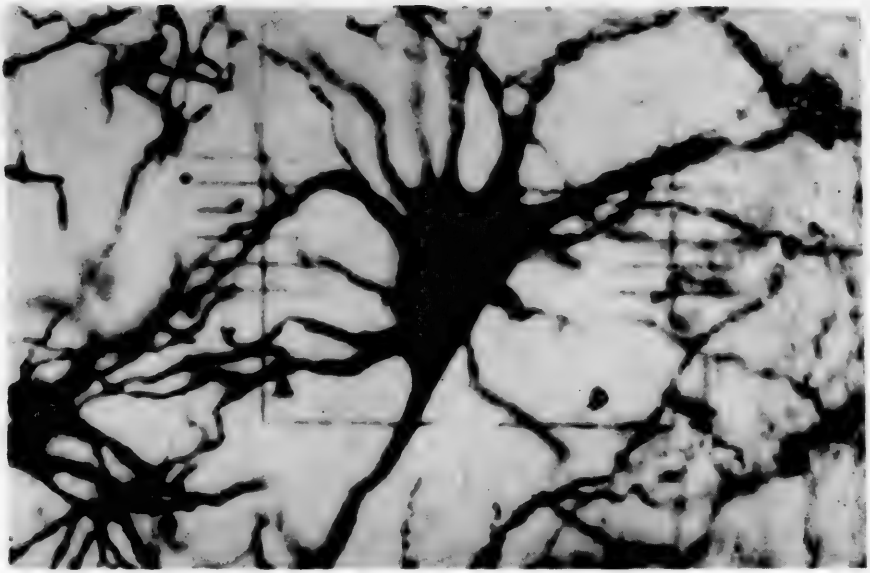

Figure 10 Photomicrograph of motor neuron from the cervical spinal cord of a cat, one of a stereo pair, showing dark scale and dots.

The rotatable objective and scale projection system was installed on a Nikon Model L microscope. The objective used was a long working-distance ×13 with a numerical aperture of 0.21. Figure 10 shows one of the paired stereophotomicrographs taken with this microscope. It shows the dark scale and dots in the image plane.

Figure 11 shows the contour lines plotted from such a print as Figure 10. The contour-line intervals are 2.5μ.

Figure 12 is a photograph of a three-dimensional model made along such contour lines.

Conclusion

Three-dimension measurements under the microscope have until now been difficult. The equipment described not only enables stereophotomicrographs to be taken but also, as in photogrammetry, contour lines to be plotted. As a result, three-dimensional form study and quantitative measurements of the volume and surface area of cytological specimens have been made possible.

In this study, use was made of a nerve cell specimen for experimentation and to evaluate the apparatus. However, stereophotogrammetry of a nerve cell is only one example of the many and wide applications possible, and undoubtedly this apparatus can be applied to other research in the medical, biological, and engineering fields.

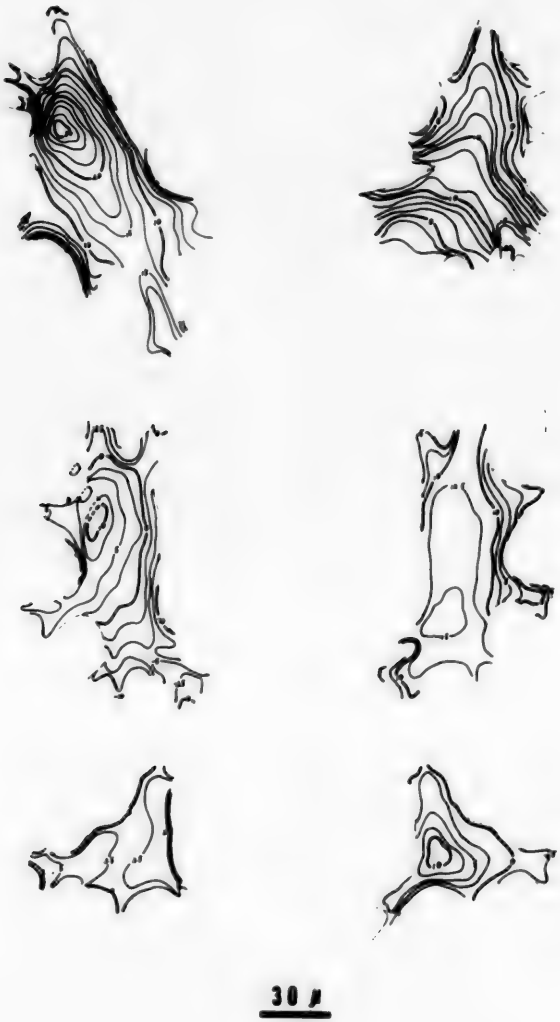

Figure 11 Contour line plots of motor neurons (medulla spinalis).

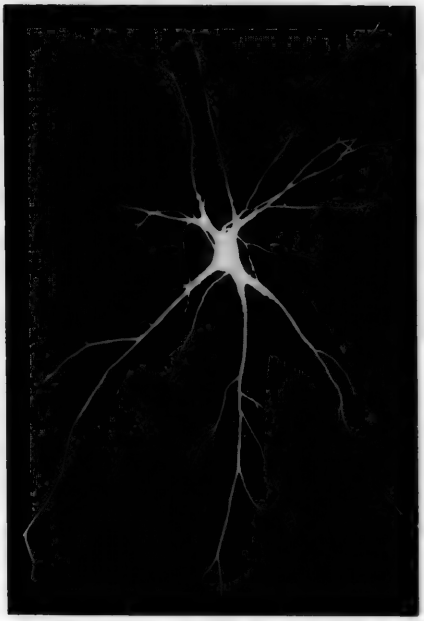

Figure 12 Three-dimensional model made along contour lines.

Acknowledgment

I am pleased to state that this study was made possible with the help and cooperation of Dr. Hajime Mannen, Professor of Anatomy, Tokyo Medical and Dental University, on a grant provided by the Ministry of Education of Japan.

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Received 19 October 1967

editor's choice

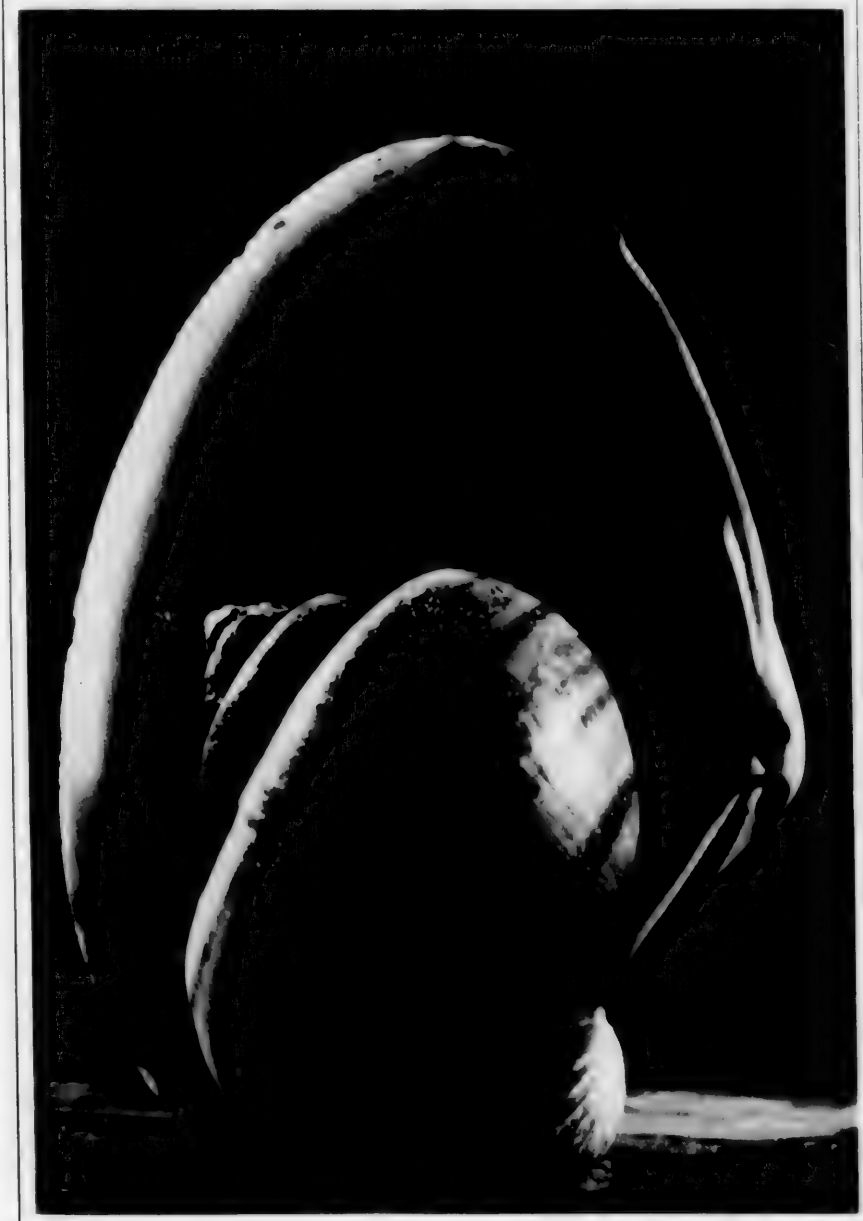
Oriental Rat Flea

Xenopsylla cheopis (Rothschild), photographed by Lewis W. Koster, New York City, received First Award (Photomicrography, black-and-white) at the 38th Annual Meeting of the BPA, held in Los Angeles, August 1968.

Mollusk Motif

Shells of a snail (*Pomacia paludosa* (Say)) and a clam (Mactridae sp.) captured the imagination of the creator of this photograph, Dr. W. Brooks Hamilton of Lexington, Ky. Dr. Hamilton, an award-winning photographer, is well known for his nature pictures.

Oriental Rat Flea — Lewis W. Koster



Mollusk Motif W. Brooks Hamilton

Infrared absorption angiography

EARL CHOROMOKOS, KYUYA KOGURE, and NOBLE J. DAVID

This report describes a new method for the angiographic study of surface vasculature. The method employs a "false"-color reversal film, which in one of its layers is sensitive to the near-infrared frequencies used to record the passage of a dye that efficiently absorbs radiation in the same spectral band. Photographs of the pial vessels of the dog brain made with this film during the passage of the dye constitute contrast angiograms in which the absorbent dye is recorded dark on brightly rendered adnexa in the subject.

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Materials and methods

Film data

Kodak 35-mm Ektachrome Infrared Aero Type 8443 film was employed in the first experiments. This false-color reversal film, which has a speed rating of 100 ASA in daylight, has three image layers, one sensitized to green, one to red, and one to infrared spectral frequencies. The frequency limit of infrared sensitivity is about 900 mμ. Sensitometric data for this film provided by Eastman Kodak Company (1967) are given in Figure 1. The spectral sensitivity curves show that sensitivity of the yellow-forming layer is high at frequencies of less than 600 mμ, and that sensitivity of the magenta-forming layer is high at frequencies of less than 700 mμ. The peak of this latter layer is about 650 mμ. Sensitivity of the cyan-forming layer is high in the low-blue and green range, falls to a valley at 550 mμ, and attains a fairly high plateau over the range of 550 to 900 mμ. Our technique was concerned only with spectral frequencies above 500 mμ. Blue light, which exposes all color-sensitive layers, had to be excluded by use of an appropriate filter at the lens aperture. We used a Kodak Wratten No. 12 yellow gelatin filter, which screens out wavelengths shorter than 500 mμ (Figure 1). It should be noted that the latitude of this film is very narrow, about one-half stop. Its resolving power is given as 30 lines per mm. A standard processing method, E-3, described in the instruction

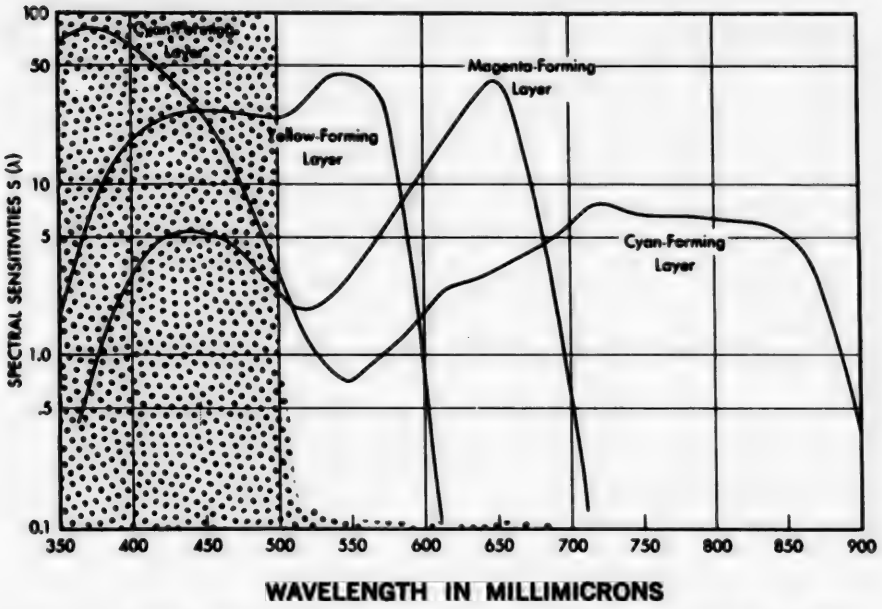

Figure 1 Spectral sensitivity curves of Ektachrome Infrared Aero film, Type 8443. Stippled area from 350 to 550 mμ depicts wavelengths eliminated by Kodak Wratten No. 12 filter of gelatin squares.

sheet supplied with the film, was used to provide the optimum infrared differentiation. All processing was done in the local supplier's laboratory.

Indocyanine green (obtained as Cardio-Green, manufactured by Hynson, Westcott & Dunning, Inc., Charles and Chase Streets, Baltimore, Md. 21201) dissolved in plasma has a highly effective spectral absorption at the longer visible-light and infrared wavelengths, and peak absorption occurs at 800 mμ (Fox and Wood, 1960) (Figure 2). This absorption characteristic results in reduced exposure of the cyan-forming or infrared-sensitive layer of the film, a layer well removed from the frequency range of spectral sensitivity of the two other layers. The dye thus effectively absorbs these components of a white-

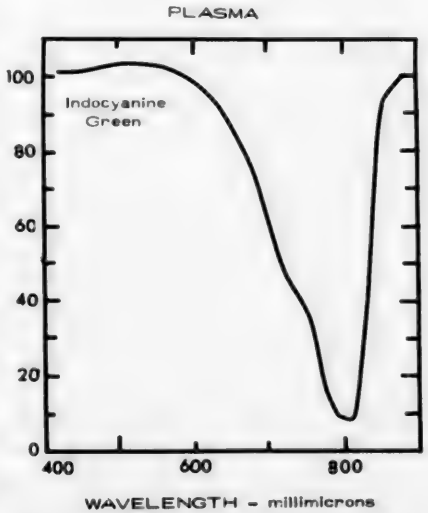

Figure 2 Spectral absorption curve of indocyanine green in plasma (after Fox and Wood).

light illuminating source. These data apply to spectral transmission characteristics; we do not have reflective spectrometric data at present. No toxic effects attributable to the dye have been noted in animals or in man when the dye has been used in the low-saturation dosages. Another important biologic feature is the rapid clearance of the dye by the liver almost completely within its first passage; this characteristic makes recirculation negligible and allows repeated photographic exposures in rapid succession without background interference from residual dye in the plasma of the subject.

Photographic recording instrument

Rapid-sequence still photographs, three or four per second, were taken with a motor-driven 35-mm Nikon F camera equipped with a 55-mm *f*/3.5 Auto-Micro-Nikkor lens and a No. 2 closeup attachment lens. Movies were recorded with a Bolex H16 reflex camera at speeds varying from 16 to 64 frames a second. In all experiments a Kodak Wratten gelatin filter No. 12 was placed over the lens. Illumination was provided by two 500-watt Sylvania B-2 Super flood lights, each placed about 12 inches from the surface of the brain, and each at about a 45-degree angle from the camera–subject axis. At the time of the first experiments, only rolls of 20 exposures were commercially obtainable. A very limited supply of experimental 16-mm movie film was made available through the special effort of Mr. H. Lou Gibson and his collaborators in the Research Division of the Eastman Kodak Company. The motion pictures were even more informative than the stills.

Angiography of the brain surface

Angiographic sequences were recorded on the surface of the brain of seven anesthetized dogs. A volume of 7.5 mgm of the dye was injected into the carotid artery through a branch of the thyroid artery. After wide parietotemporal craniotomy and reflection of the dura, the brain was kept moist and warm by irrigation, and repeated studies of the passage of this dye were recorded on the infrared-sensitive film. It should be noted that the dye was not visible on direct inspection. The distribution of the middle cerebral artery is depicted in photographic sequence (Figure 3). The pictures comprising Figure 3 were selected from a series taken at three frames per second. In the control infrared photograph (Figure 3, *upper left)* some differentiation of larger arteries from veins is made apparent by the lighter and more yellowish tint of the arteries in contrast to the brownish color of the veins. Dye appeared first in the main trunk of the artery (Figure 3, *upper middle)* in a dark-green color, which is in strong contrast to the orange-yellow background. It may be seen to pass in successive phases into arterial capillary and venous stages of filling (Figure 3, *upper right and all in lower row*). Exact timing of each slide can easily be determined by checking the frame number in the sequence.

In the capillary phase, when dye filled the superficial brain tissue, it imparted to it a royal-blue color. Initial capillary filling was splotchy, but it coalesced rapidly to cover the entire surface, though somewhat unevenly as to intensity of color. During the venous phase, the dye disappeared quickly from the brain surface (Figure 3, *lower right*) and left no residual traces.

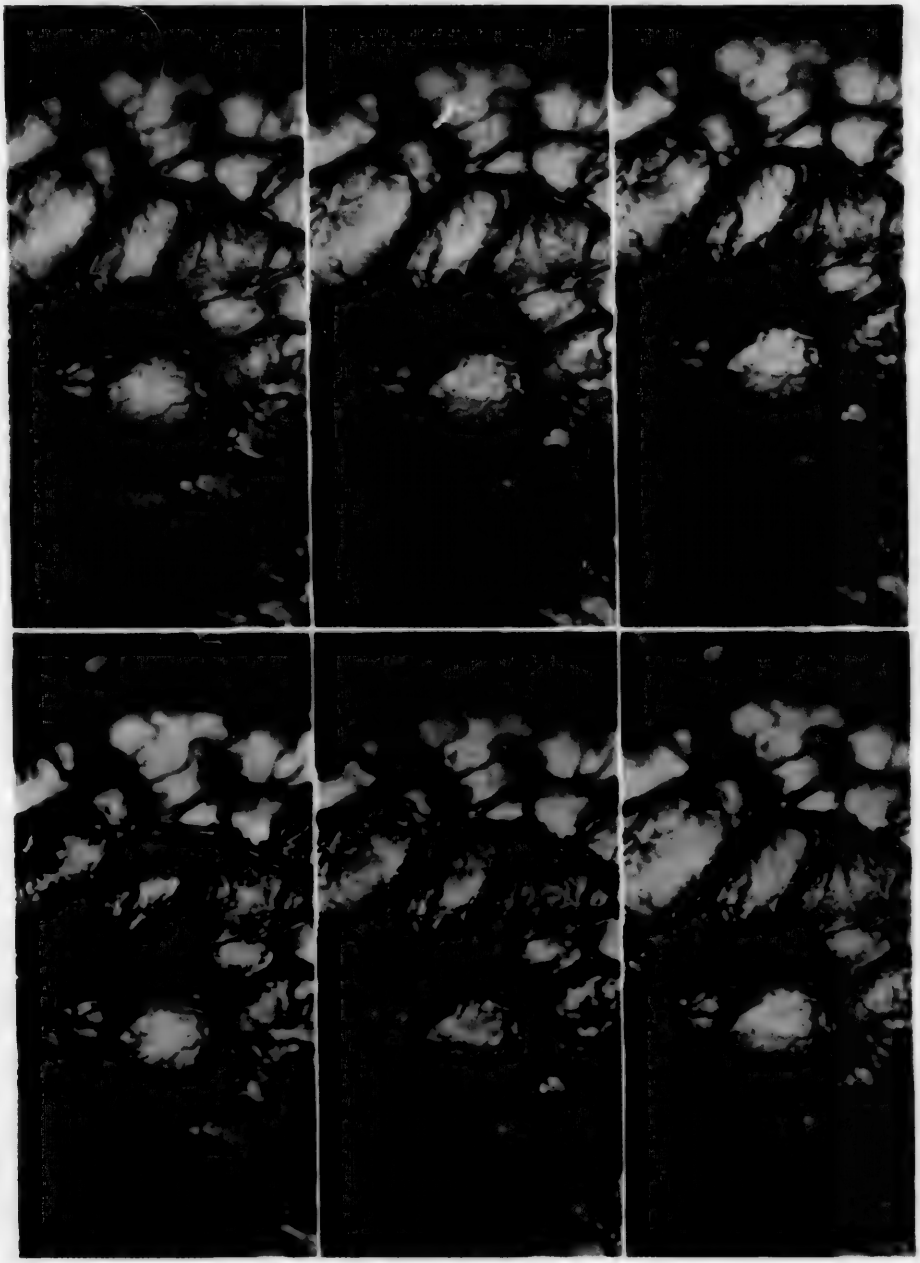

Figure 3 Angiographic sequence of middle cerebral artery of dog, showing successive stages of filling and emptying of arteries.

An additional photographic sequence, not pictured, was made in the same field after ligation of the trunk of the middle cerebral artery. When illustrations of dye flow and a control sequence were compared, dye flow showed a collateral reversal in a major arterial trunk. The dye was also delayed in its time of arrival at the pial vessels and arteries of frontal origin. Preliminary studies of this technique applied to the fundus of the eye, the surface of the bowel, and the surface vascularization of skin grafts indicate that it will be possible to obtain adequate exposure and contrast in these areas. Such applications cannot be discussed further before a larger experience has been acquired.

Unlike fluorescein-contrast angiography, illumination is not a critical problem in this method. Light intensity adequate to expose 16-mm cinefilm at 64 frames per second is easily achieved, and higher speeds and much greater magnification are possible. Moreover, a background photograph of the anatomy, being part of the angiographic sequence, eliminates the need for comparison with a color control. Slow-motion cineangiograms of the brain surface by the infrared absorption technique are remarkably useful in analyzing the pattern and speed of dye-filling under varying conditions.

Summary

The authors describe a contrast angiographic technique employing a principle, which, to their knowledge, has not previously been reported. The method employs the combination of infrared-sensitive color film with a dye that efficiently absorbs radiations in this spectral band. The authors' application of this technique in studying the surface vasculature of the brain, and its potential extension to other uses in surface angiographic studies are discussed.

Acknowledgments

The authors extend thanks to the Eastman Kodak Company for permission to use material for Figure 1, and to Mr. H. Lou Gibson of this company for supplying film.

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Eastman Kodak Company. 1967. Medical infrared photography. Kodak publication No. N-1. Rochester, N. Y. 84 p.

Fox, Irwin J., and Earl H. Wood. 1960. Indocyanine green: physical and physiologic properties. Proceedings of the Mayo Clinic 35:732-744.

Delivered at the 38th Annual Meeting, Biological Photographic Association, Inc., Los Angeles, Calif., 12-15 August 1968.

meetings calendar

39th Annual Meeting
Biological Photographic Association, Inc.
August 18 - 21, 1969
Kahler Hotel
Rochester, Minnesota
(see details on page 74)

40th Annual Meeting
Biological Photographic Association, Inc.
held jointly with the
Association of Medical Illustrators
August 10 - 13, 1970
Houston, Texas

For further information write to:
LYNN BALDWIN, RBP, FBPA
General Chairman, 40th Annual Meeting
Department of Medical Communications
M.D. Anderson Hospital
Texas Medical Center
Houston, Texas 77025, U.S.A.

41st Annual Meeting
Biological Photographic Association, Inc.
International Congress on Scientific Communications
August 23 - 27, 1971
Chateau Laurier Hotel
Ottawa, Ontario, Canada

For further information write to:
JOHN D. DEBLOIS, RBP
General Chairman, 41st Annual Meeting
National Research Council of Canada
Montreal Road Laboratories
Building M23A
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letters to the editor

You are invited to contribute to this new department comments related to the activities of the Association, the *Journal*, and the profession in general.

It is the intention of the editors to develop this department into a discussion forum, and so offer an opportunity to criticize our programs, the governing of the affairs of this Association, and the material published in this journal. Many ideas discussed in the papers may often be further expanded or improved through constructive criticism, and theories that do not really work may be corrected.

The editors hope that the readers of this publication will take advantage of the opportunity to express their opinions. Letters considered of general interest will be published in this department, over the writer's signature; other letters may be referred to the attention of the House of Delegates, the Board of Governors, the Executive Committee, or the group concerned. In the case of criticism of a paper published in the *Journal*, the author of the paper will, of course, have access to this department for the defense of his point of view.

TECHNOTES

A MULTIPURPOSE TRANSILLUMINATOR

For a long time there has been a need for a versatile transillumination method that would not overheat the object and could be used for color or black-and-white photography of medical specimens and industrial products. We have designed a transilluminator for bright-field and dark-field diffused illumination, using a new fluorescent lamp made by Lustra Lighting (ITT Lamp Division, International Telephone and Telegraph Corporation, Carle Place, N.Y. 11514), that emits light of 5500°K, suitable for use with daylight color films.

The illuminator consists of a square box made of plywood and one-half-inch white pine having specific dimensions (Figure 1). It can be used for dark-field illumination of an area approximately 8 inches in diameter, for diffused bright-field illumination of an area 18 inches square, for shadowless illumination within the box when the extra extension (Figure 1, *B*) is added, and also as a transmitted light box.

To obtain dark-field illumination, only the main unit (Figure 1, *A*) is used in an upright position, with the smaller

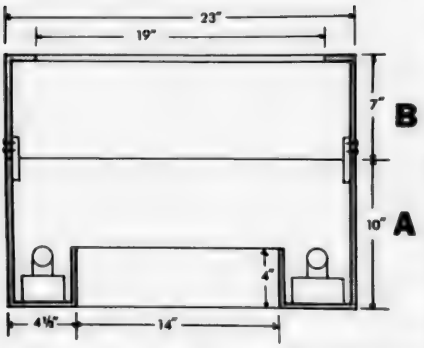

Figure 1 Cross section of total system with dimensions, showing: *section* A, main unit; *section* B, extension unit.

Figure 2 Main light unit with new NLK-5500 fluorescent lamps manufactured by Lustra Lighting.

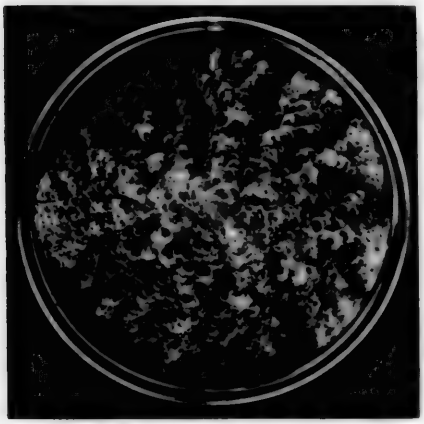

Figure 3 Dark-field illumination of *Bacillus mycoides* colonies.

Figure 4 Shadowless illumination of human kidney with a staghorn calculus (kidney stone).

opening at the bottom. A square of black velveteen is placed within the square between the lamps (Figure 2), then a sheet of polished plate glass is placed on the top of the main unit. A black sheet of paper having a center area cut out to mask a petri dish or other object to be photographed by dark field is placed on the glass. Now the object can be seen by dark-field illumination (Figure 3).

When color or black-and-white shadowless illumination is desired, the unit is used in an inverted position, with the smaller opening at the top. The desired background is placed in the bottom of the box with the specimen to be

photographed placed on it. The pictures are taken through the smaller opening of the main unit. When the system is used in this position, a 90-mm or 105-mm lens for 35-mm cameras works best, because a long-working distance is needed (Figure 4).

To photograph items such as gels, which need diffused lighting, both sections are used as they are for shadowless illumination. The unit is used as shown in Figure 1, with a sheet of opal glass on top of it and a white cover over the area between the lamps. This gives a large, evenly diffused light area that can be photographed with daylight film, without the necessity of filters.

The illuminator can be used for shadowless lighting of large areas by placing the main unit on its side and angled toward the subject, and then photographing through the smaller opening. Thus the unit can function as a large ring light.

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Received 7 September 1968

VERTICAL COPY APPARATUS

Copying radiographs, charts, or drawings on a large film with a vertical standing camera has two distinct advantages. Using a horizontal illuminator or a horizontal copy board is by far the easiest way, because this method makes gravity do the work instead of clips, tape, or pins. Masking off stray light is easily done by using various pieces of black film or cardboard. Specific areas can be selected merely by properly placing the material to be copied. A vertical or swinging copyboard is not efficient, so the obvious choice is an upright camera, and many photographers use the Polaroid MP-3 camera for this purpose. The MP-3 is a vertical copying camera that may be used with a Polaroid rollback or ordinary 4 × 5-inch film holders.

The second advantage is the 5 × 7 film, a size large enough for contact printing. The 5 × 7 print size is most often chosen because it is a finished product that may be used for viewing or publication, or for filing as a record. For our purpose, this size was made possible by adding a rigid extension above the 4 × 5 film plane, and a 5 × 7 camera back (Figure 1). This extension is as easy to attach as a film holder, and no changes are necessary to the Polaroid camera itself. The image is viewed and focused in a mirror mounted at an angle to the ground glass. A Log-Etronic contact printer is used to dodge X rays automatically, and the results can hardly be matched in any other way.

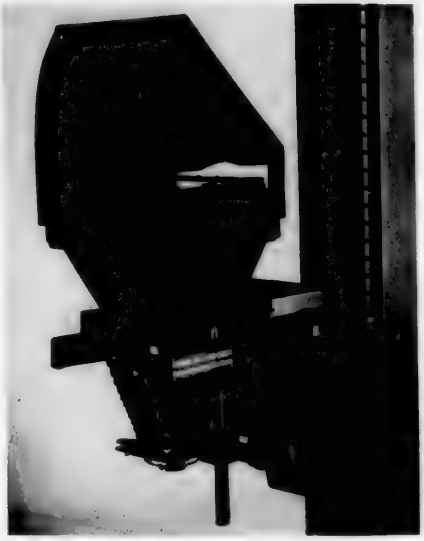

Figure 1 A 5 × 7-inch clinical camera, to which have been added wooden sides and a 4 × 5-inch film holder attached by sliding clips. The viewing hood contains a first-surface mirror.

The choice of equipment for vertical copying is limited. Commercial copy cameras are either too large and too expensive, or not suitable; most are made for the printing trade. Some have vacuum backs, and require a special darkroom. Small biological photo laboratories must, then, often make a copying set-up from components. In our case, the easiest solution was to use the MP-3.

The extension is made from the back of an old Eastman clinical camera. The sides are made of wood, and the bottom on which it stands is made from half of a 4 × 5 holder. This fits the clips of the Graflok-type back on the MP-3.

A first-surface mirror is fastened into the viewing hood. It gives a very clear image easily seen by the operator. By mounting the camera on a low stand, a convenient working height can be arranged.

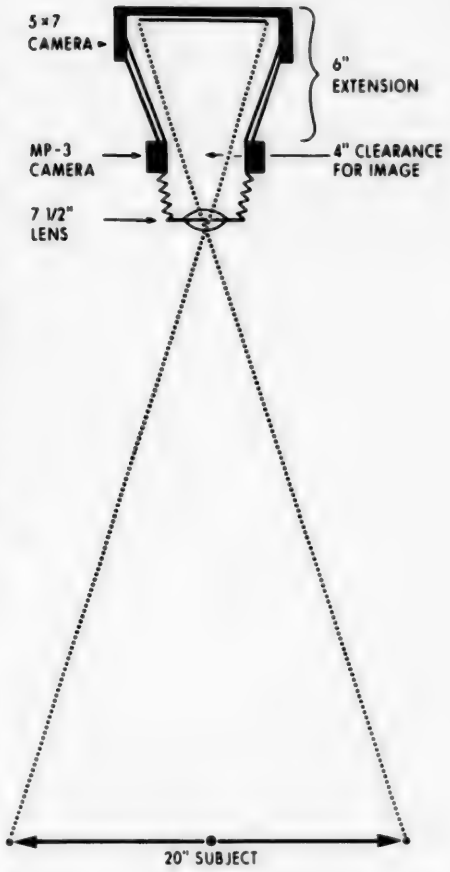

Figure 2 Approximate dimensions of the 4 × 5-inch Polaroid MP-3 camera and 5 × 7-inch converter.

Dimensions are of critical importance in this design. The image must clear the MP-3 body from the lens to the film. The bellows must have sufficient length also. In our work, the greatest reduction required is that of a 20-inch chest film to the 5 × 7 film size. Most radiographs and other copy material is equal in size or smaller. A 7½-inch lens makes this reduction possible. This lens is also suitable for 1:1 copying before the bellows is fully extended.

There is no image cutoff (Figure 2). Lenses of shorter focal length may also be used to obtain a 5 × 7 image, although their covering power should be first carefully considered.

The 5 × 7 adapter does not impair the use of the MP-3 camera in its normal way, since the converter and the special lens may be quickly removed. Therefore, for a very small investment what could be a very big problem is solved.

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RAPID COLOR 35-MM TRANSPARENCIES FROM BLACK-AND-WHITE NEGATIVES

Slides of line or graph charts and typewritten tables are more interesting and more easily read when they are color-toned. My method for producing such slides is probably new and is definitely rapid.

With a 55-mm Micro-Nikor lens on my Nikon F, I am able to get a 1:1 image without exposure change or compensation. Using 35-mm Kodalith Ortho, Type 3 film, I expose every negative for one second at $f/11$, when copying typewritten material on white bond paper. For line or graph charts, an IBM executive typewriter is preferred because the type is clear and carefully spaced. When copying ortho negatives for positive slides, I expose for 1 second at $f/8$. The film is developed in Kodalith liquid developer for 1½ to 2½ minutes at 68°, then fixed until clear and washed for 5 minutes. Under the red 1A safelight the film can be inspected during the developing and pulled from the developer when the film is black on one side and gray on the other; prolonged development may cause the images to block up.

Immediately after washing, the color is added by a dye process in which about 60 cc of Dr. Martin's dye is mixed with 6 ounces of water and a capfull of photo-flo. I premix many different colors and store them in small plastic bottles. Some colors are stronger than others, and more or less of them may be needed. Occasionally it is necessary to replenish the mixtures with more dye.

Holding the film at both ends with a spring clothes pin (Figure 1) I move the film back and forth through the dye for about 1 minute. Then I drain the film and hang it up to dry. Drying takes about 10 minutes. The slides are then ready to be mounted. By this process, 20 to 36 glass-mounted slides can be completed in an hour. Different colors may be used on one roll of film to separate ideas by color groups. All that is needed is to cut the strip where necessary and dip the films separately into dyes of different colors. To outline a talk, the title slide may contain many colors, a different one for each line being brushed on with a number 1 red sable brush. Dr. Martin's dyes will not

Figure 1 Applying Dr. Martin's dye to the film.

fade or rub off; however, if for any reason you want the dye removed, all you do is rewash the negative with water and photo-flo, and your negative is like it was originally.

If you are concerned about not having a negative for making prints or for filing, you have merely to project these slides onto paper from your enlarger. All colors except red and orange will reproduce perfectly on Kodabromide papers, and any color on Polycontrast or Varigam papers. A separate negative file may still be kept by shooting two exposures of the copy material, but this is hardly necessary. The slide can be recalled when prints are wanted.

When a negative slide is projected the glare of white letters and graphs on a white screen is usually hard to read and thus is annoying and monotonous to an audience. This method enables slides to be read clearly and holds the audience's attention.

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GROSS-SPECIMEN PHOTO CABINET

Innovations usually result from a recognized need. Such a need was apparent at our hospital as the frequency of calls requesting photography of autopsy on surgical specimens increased. The construction of a sturdy device, simple to operate yet assuring good photographic results, for photographing gross specimens when a hospital staff photographer was not on duty seemed necessary. The cabinet we designed and built to satisfy this need has been in use for four years and has given very satisfactory results. It is simple and sturdy, and it can be locked as a self-contained unit.

The cabinet is made of 3/4-inch fir plywood and measures 60 inches high, 20 inches wide, and 32 1/4 inches deep (Figure 1). The top doors are so constructed that as they are swung open they are stopped automatically at a predetermined position by magnetic stops. Thus, the two Strobe lights mounted on the doors (Figure 2) will always be in the exact spot to supply complete coverage and proper depth of lighting. These doors are also used for storage of film, charge slips, pencils, and rulers, as well as instructions for the operation of the cabinet and camera.

Immediately back of the doors on the left side of the cabinet is a small door of a double compartment where larger accessories are stored. We have found that used X-ray film provides an excellent background for gross-specimen photographs. There is adequate space in this compartment for a supply of this film and sheets of cardboard, which are also used for background (Figure 3).

At the bottom rear of the cabinet is another compartment, which is used for storing the Strobe power pack. The doors to all compartments are locked from the inside of the cabinet so that a single lock is all that is necessary to open the cabinet. The lower cabinet front door opens to the area containing the Strobe for backlighting. It is fitted with grooves on each side for adjusting the height of ground glass and filters for the different background colors. On the shelf below the Strobe light is space

Figure 1 Cabinet under construction. Only the bottom door has been put in place.

for storing the filters. The specimen area is a clear plate glass. When the subject is to be backlighted, the glass surface is used for the background. When an opaque background is desired, a ¾-inch plywood board is slid into place over the glass.

The camera stand is a Leitz Micro adjustable. It carries an Exakta camera with an Auto Guinaron F2 lens with ground glass focusing (Figure 2). The lens has an extended lever around the barrel for fingertip focusing, and with micro-adjustment it is possible to obtain an image of any size.

To use the unit, the operator merely unlocks the cabinet, swings the doors open until they strike and are stopped

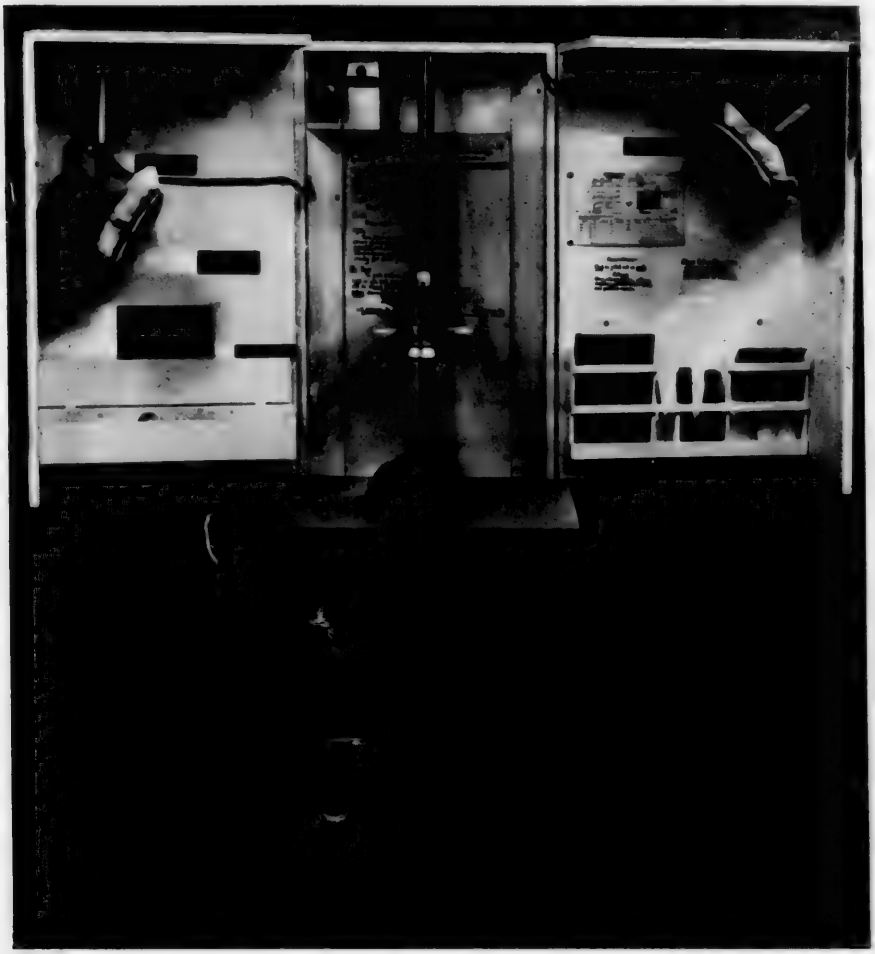

Figure 2 View of cabinet in use, showing opaque background in place.

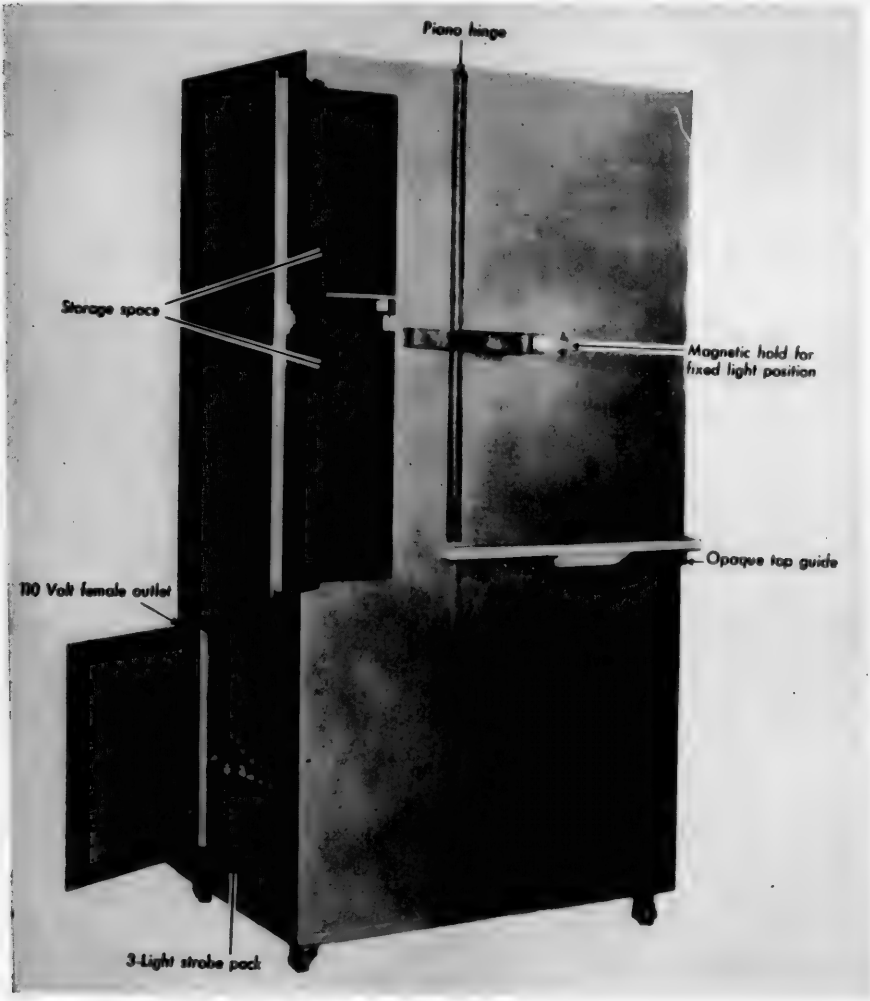

Figure 3 Rear and left side of cabinet, with front closed.

by the magnetic stops, pushes the button that activates the modeling lights and Strobe unit, arranges the specimen on the center of the background, adjusts the camera height for the desired size of picture, focuses, and snaps the picture. The use of this gross-specimen photo cabinet has eliminated the need for obtaining the services of an off-duty photographer without lowering the caliber of the photography.

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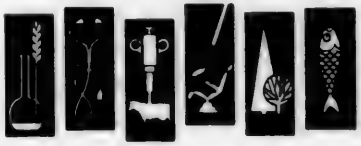
SHOPTALK



in the health sciences

THE BIOLOGICAL PHOTOGRAPHER IN TELEVISION

The biological photographer today should be a specialist in many media. Because of the current advancement in all types of photographic equipment, photomicroscopes and clinical cameras, many clinicians and researchers are making photographs for themselves that are of average or above-average quality. To a number of biological photographers this is a serious challenge. It should not be, and it need not be.

As times and techniques have changed, so should the biological photographer change. His role in the field of scientific photography is that of a specialist. His knowledge, skill, and experience should place his work and abilities far above those of the man he assists. The field of scientific television is ready and waiting for him and many scientific photographers have picked up the challenge.

Where can an institution today find a television producer-director who has knowledge in the field of microscopy, surgical techniques, and anatomy, as well as all the other biological photographic specialties? Can they find this man in the television industry? In general, no. He can only come from the allied field of scientific photography or scientific cinematography. I have worked for 13 years in the field of scientific television and have yet to meet a television producer-director who does not have to rely on the scientific photographer to make a teaching video tape of a scientific subject. I now address the remainder of this article to you, the biological photographer.

As a top scientific photographer you have all the photographic knowledge necessary for the judgment of image quality, composition, and subject control. Each of you has a knowledge of optics and lighting, and you understand contrast and shading. It is expected that you are qualified and knowledgeable in the field you are working in. In working with television it is only necessary for you to transfer this knowledge to a new medium that is designed to produce images similar to those in photography. Scientific television utilizes your photographic knowledge and abilities.

With new equipment you must become experienced in the operation of electronic controls that make and record your image for you. As the video taping of scientific procedures or techniques is gradually replacing the use of film for a number of teaching demonstrations, I would like to share with you

one approach to the making of dental video-tape sequences with a single television camera. The dental procedure is the step-by-step fabrication of a patient denture.

The first requirement is a producer-director or scientific photographer who can assist the teacher in organizaing the television outline or script. Assistance should be given for illustrations, narration, lighting and background, and all areas that will help demonstrate the technique to be shown. This is the same procedure that is used in the making of a slide sequence or film. Next, you must have a good EIA television viewfinder camera with a 10:1 zoom lens. This camera will add electronic image quality to the tape. Naturally, a good pedestal and dolly with a television cradle head will add smoothness to the production. The video-tape recorder I use is a Sony PV120U with an electronic editor. There are a number of makes on the market; some are to be avoided, others are excellent. Again, the image quality of the video-tape recording you produce is directly related to the electronic quality of your video-tape recorder. A one-half-inch video recorder will not produce results equal to a one-inch or two-inch video-tape machine. There are no bargains in the television tape business and you receive value commensurate with your monetary outlay.

With the above television equipment you will need your regular photographic lighting and backgrounds. If the tape is to have only the video signals recorded, then no audio control or microphone is needed. With all good video recorders the audio can be narrated onto the tape later. If live sound is to be recorded, the tape recorder should not be in the same room where the production is being made, as the recorder is quite noisy.

With all of your electronic equipment and script material assembled and set up you are ready to produce a video tape that can be very professional.

Making video tapes can be as challenging and rewarding as making motion pictures and it has one great advantage: your visual image is immediately available for playback and viewing at any time. With sophisticated equipment such as multiplexers and switcher faders, dissolves and special effects can be handled. Your control of any scene is now possible and as you want it. As with everything we do in scientific photography or television we must first visualize or plan the production. Then we must make it become reality. In any production, things do not just happen. As a scientific photographer you have the capabilities, with the right equipment, of producing a video tape of good quality.

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in medicine

A SIMPLE METHOD FOR TRANSILLUMINATING THE MAXILLARY SINUSES

The successful use of a cone over the head of an electronic flash unit to photograph the skull of a hydrocephalic infant by transillumination (Figure 1) led us to a search of the medical literature for other uses of this fascinating and diagnostically valuable method of taking photographs.

Shurtleff, Foltz, and Fry (1966) reported using a photoelectric cell within the cone for simultaneous incident illumation. The cell was connected to a slave unit directed toward the ceiling. With this technique they were able to provide balanced transillumination and incident illumination for various lesions. Their paper encouraged us to continue our efforts to expand the use of this technique in other areas.

A sinus infection led me to a physician. His examination included transillumination by a penlight held against the cheek below the eyes and observation in my open mouth; and I immediately thought of reversing the method of transillumination to reproduce a photographic image that would be a permanent record for references as treatment progressed.

In our department we had three cones with openings of progressively smaller diameters, but none were small enough to fit comfortably within my mouth. We located a cardboard container that fitted the smallest open end of one of the flash head cones. After cutting out the metal end of the container and cutting a slot into the top sides, I taped the container to the cone.

Figure 2 shows the head of our Stroboflash IV unit, the flash head cone lined with aluminum foil, and one of the containers we used.

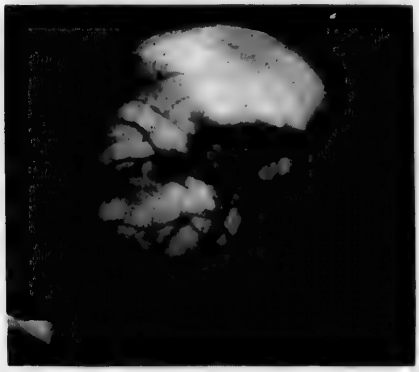

Figure 1 Skull of a hydrocephalic infant.

Figure 2 Head of Stroboflash IV unit, flash head cone, and cardboard container.

Figure 3 Height of sinus infection photographed by use of transillumination.

So far in our study, we have used Anscochrome 500 Daylight film with normal processing. A Graflex Stroboflash IV, set on full power, has been our light source. A more powerful electronic flash and forced processing of the film might give better results than those we have obtained so far.

Figure 3 is a photograph of a patient at the height of sinus infection taken at a shutter speed of 1/50 sec at f/2.8 of a 90-mm lens. All lights in the room were extinguished. The photo shows a difference in the density of the two sinuses.

Until now, we have only experimented with this technique. We have approached the oral surgeons on the staff in the hope that they might find the method valuable for recording cases of oral antral fistula and certain tumors and cysts. Also, if the otolaryngologist who joined the clinic staff recently finds merit in the technique, we will have metal cones made to fit in the patient's mouth with ease. These cones, with a more tubelike, smaller end, will be directed upwards toward the maxillary sinuses. As the cones will be chrome plated or of stainless steel, they will be easy to sterilize.

JOSEPH N. TIEDT
Medical Photography Department
Gundersen Clinic Ltd.
La Crosse, Wis., USA 54601

REFERENCE

Shurtleff, D. B., E. L. Foltz, and D. Fry. 1966. Clinical use of transillumination. Archives of Diseases of Childhood 41:183.

Delivered at the 38th Annual Meeting, Biological Photographic Association, Inc., Los Angeles, Calif., August 12-15, 1968.

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Superior craftsmanship in still or motion picture photography of biological subjects.
Ability in photographic research in new methods or materials.

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Two sponsors are required, one of whom must be a Fellow. The sponsors should be well acquainted with the candidate's work and ready to furnish the Board with details of his experience and achievements. Those who wish to sponsor a member whom they believe to be eligible should request a Fellowship Application form from the Secretary of the Fellowship Committee: E. Lynn Baldwin, RBP, FBPA, Department of Medical Illustration, M. D. Anderson Memorial Hospital, Houston, Texas 77025.

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There are no page charges. A reasonable number of black-and-white illustrations are usually accepted. The cost of plates for color illustrations, however, is required to be borne by the author or his employer or sponsor.

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3

VOLUME 37 NUMBER 3 JULY 1969

JOURNAL OF THE biological photographic association

J. BIOL. PHOTOGR. ASS., VOL. 37, NO. 3, P. 121-176, JULY 1969

Cover Photograph

This picture, taken at the Montreal Rehabilitation Institute by an unknown photographer, shows a teen-age high school student, Miss Clare Scullion, the recipient of hydraulic arms The new devices, produced at the Northern Electric Company, aim at providing more adequate replacement of missing arms; they will perform some of the normal movements and the functions of hand, wrist rotation, elbow and shoulder flexion and extension, and allow for easy passive positioning of the shoulder in abduction and rotation. The hand, available in two sizes, can readily be adapted to either the left or right arm. In the photograph, it appears that this artificial hand may be able to write easily, but, strong determination and long practice are doubtless required to master the intricacies of its proper use. Nevertheless, these hydraulic arms, designed by Mr. Helmut Lukas, which have several advantages over previous mechanical and electromechanical prosthetic devices, are the human intellect's answer to a very acute need for artificial limbs for the very young, a need created by the Thalidomide disaster.

The *Journal of the Biological Photographic Association*, published quarterly in January, April, July, and October, is the official publication of, and copyrighted © 1969 by, the Biological Photographic Association, Incorporated, an international society. Membership in the Association includes subscription to this journal.

Information for contributors is on the inside back cover of this issue.

Manuscripts, proofs, and related correspondence should be sent to the editorial office, P. O. Box 333, Terminal A, Ottawa, Ontario, Canada. Reprint orders should accompany returned proofs.

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bpa

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The Association is an international professional organization of scientific photographers and other communications specialists who work in the natural and health sciences. Persons interested in scientific photography, but whose vocational status does not qualify them for active membership, may join the Association as affiliate members.

The B.P.A. was founded at Yale University, in 1931, by a group of scientific photographers, to provide a forum for the dissemination of information on methods, techniques, materials, and instrumentation as applied to scientific research and teaching. The B.P.A. has now over 20 chapters in the United States, Canada and India, with over 1000 members. There are also numerous members-at-large in many countries throughout the world.

Three classifications of membership are available: active, affiliate and sustaining. In recognition of professional excellence, award plaques and certificates are conferred annually for the best scientific paper published in this journal and presented at the annual meeting, and for outstanding contributions to still and motion pictures and TV tape exhibits. Fellowship in the B.P.A. is conferred for significant achievements and meritorious contributions to the advancement of photography in the biological sciences.

Annual meetings are held every autumn for the purpose of presentation of scientific programs of papers, workshops, scientific and commercial exhibits, and refresher courses. Regional and chapter meetings are also held.

The B.P.A. publishes this journal and the Newsletter, which informs members about chapter activities, personal information, and employment opportunities for scientific photographers.

The B.P.A. has established and maintains a Board of Registry for the purpose of examining and certifying qualified scientific photographers. The aim of this certification program is to raise standards and provide criteria for those interested in employing qualified scientific photographers. This program has been established in consultation with the United States and Canadian medical associations, hospital associations, dental associations, the American Institute of Biological Sciences, and several other influential professional societies.

Further information about the B.P.A. may be obtained from Mr. R. M. Christopher, Executive Secretary, P.O. Box 12866, Philadelphia, Pa., U.S.A. 18108.

Inquiries regarding the Certification Program are to be addressed to the Secretary of the Board of Registry, Mr. Will E. Renner, Medical Illustration Service, School of Medicine, University of California, Davis, Calif., U.S.A. 95616.

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meetings calendar

39th Annual Meeting
Biological Photographic Association, Inc.
August 18 - 21, 1969
Kahler Hotel
Rochester, Minnesota
(see Prospectus on pages 129–133)

40th Annual Meeting
Biological Photographic Association, Inc.
held jointly with the
Association of Medical Illustrators
August 10 - 13, 1970
Houston, Texas

For further information write to:
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International Congress on Scientific Communications
August 23 - 27, 1971
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in black and white

Not long ago scientific photographic establishments were usually part of some other department of a research or educational institution. In a medical school or a teaching hospital, photography often belonged to the department of pathology, although it served all departments of that institution. Similar also was the case in biological research establishments, where photography was part of entomology or some other department.

Today, in many establishments photography is part of a scientific communications department that also engages in motion picture production, educational television, photo-optical instrumentation, art, design and drafting; and some of the scientific photographers may all of a sudden be faced with a new problem — that of managing a department.

Some institutions maintain fairly large communication departments, with several dozen employees and an inventory amounting to a few hundred thousand dollars. To manage such a department is no minor task. Its success or failure depends greatly on the managerial proficiency of the department head.

A manager strives to so direct his procedure that he will arrive at a desired objective; he originates, plans, and follows things up. The management of a department is a skilled occupation; it requires competence in the management of things, people and situations.

The head of a scientific communcations department must know the objectives of the establishment of which his department is a part. He must know precisely what the executive expects of him in his operation and effort toward a definite objective. He should be consulted during the making of plans that affect his department, and he should have the authority to carry out his obligations. No one should be expected to bear responsibility without the power of effective action.

To perform competently and smoothly, the head of a department must have good technical qualifications, a sound knowledge of the fundamental principles of good administration, a broad intellectual outlook, a high sense of honor, and an appreciation and comprehension of human relationships. The head of a department must be a true leader in every respect; he must lead his employees to a full un-

derstanding of every problem, however complex, and he must secure their cooperation in working out the best possible solution for every requirement.

Fundamental understanding of people is a very important qualification of every department head. He must have the mental and moral strength to tolerate every race, color, creed, nationality and idiosyncrasy but, on the other hand, he must supress his own grouchiness, impatience, temperamental outbursts, arrogance, favoritism, or inconsistencies. Bustling manners and a commanding voice are not a proof of good leadership.

Another very important qualification is the ability to make decisions and take substantial risks with reasonable equanimity. A good manager will examine all pros and cons, if necessary seek advice, and arrive at a conclusion without undue delay. A person who is not sure of himself will display strong tendencies to procrastinate every time a decision is needed and has to be goaded by the lance of authority.

Success in managing a department brings an emotional lift of no small magnitude, but there are also some constant frustrations and disappointments. The department head should have poise, wisdom, suppleness of mind, courage, energy, determination, and ability to keep going under any circumstances.

Good organization is of the utmost importance in every successful operation. The department head must be able to delegate authority and distribute duties or functions among his employees in such a way as to operate at high efficiency, maintain the required production volume and quality, and meet deadlines, all by the best method and at the lowest cost. It is the manager's responsibility to detect any discrepancy between a worker's potential capabilities and his duties, to ascertain that his work is not overtaxing or undertaxing his ability. Duties that are too demanding will result in frustration and substandard production; assignments that demand too little will soon deplete the worker's interest. It is only when the complexity of the work taxes the full ability of the worker that the work constitutes an interesting challenge to him, justifies satisfactory remuneration, and brings much happiness from successful accomplishment. If unutilized potentials of employees are not detected and duties assigned accordingly, many human resources may be wasted and workers will never be truly happy in their work. The department head should always treat his staff members as human beings, harness their desires, teach them how, and criticize only in a constructive way.

By transforming power over people to power with people, the department head eliminates job tensions and creates a happy working atmosphere. The workers will be ready with a smile; they will be glad to be working in that department.

Of course, there is much more to being a good department head than this summary presents. Management is a full-fledged profession that requires much study and practice. Constantly increasing demands for effective scientific communications result in a constant growth of communication departments, a growth that, in turn, requires better and more knowledgeable management. The biophotographer who only a few years ago operated all by himself or with only one assistant is now often responsible for three or four staff members, and in a not too distanct future he may have to manage a department employing 10, 20, or 30 people. If the biophotographer wants to keep abreast of all that is contemporary and be rightfully in charge of his affairs, he must prepare himself for this new role of a department head by becoming a multimedia communications expert with adequate managerial knowledge and experience.

Stanley Klosevych

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Prospectus

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Before the Annual Meeting, five 12-hour courses will be given. Tuition fee for each course is $25.00. Enrollment for any course limited to 40 students.

Photography in the Natural Sciences (8 hours lectures, 4 hours workshop)

Instructor: Hans S. Dommasch, RBP, ARPS, FBPA
University of Saskatchewan, Saskatoon, Sask., Canada

Small Object Photography (8 hours lectures, 4 hours workshop)

Instructor: Charles P. Hodge, RBP, FBPA
Montreal Neurological Institute, Montreal, Que., Canada

Motion Pictures (8 hours lectures, 4 hours workshop)

Instructor: John Paul Vetter, RBP, FBPA, FRMS
Western Pennsylvania Hospital, Pittsburgh, Pa.

Photomicrography (8 hours lectures, 4 hours workshop)

Instructor: Robert F. Smith, RBP, FBPA, FRMS
Brookhaven National Laboratory, Brookhaven, N.Y.

Principles of Professional Scientific Photography (12 hours lectures)

Instructors: Percy W. Brooks, RBP, FBPA
Cornell Medical Center, New York, N.Y.
Lawrence R. Reynolds, Jr., RBP
Milton S. Hershey Medical Center, Hershey, Pa.

For further information and registration applications write to the Course Coordinator, Mr. Percy W. Brooks, RBP, FBPA, 1300 York Avenue, Room A-162, New York, N.Y. 10021.

ANNUAL MEETING

18-21 AUGUST 1969

Kahler Hotel

18 AUGUST, MONDAY

Opening of the 39th Annual Meeting

Stanley J. McComb, Chairman, Upper Midwest Chapter BPA

Dr. L. Emerson Ward, Chairman, Board of Governors, Mayo Clinic

Lardner A. Coffey, General Chairman, 39th Annual Meeting

First Business Meeting

Howard E. Tribe, President BPA

President's Luncheon

Professional Education for Biophotographers — A Panel Discussion

Will E. Renner, Donald H. Fritts and Nicholas Graver will discuss the RBP examination;

John Trauger will report the survey results, and explain the status of the Biomedical Photography Program at the Rochester Institute of Technology;

George Tanis will present an analysis of a job interview;

Jack de Bruin will report on courses in basic medical photography at Chicago Medical School

Social Activities

Get-Acquainted Coffee for Ladies

An Evening on the Mississippi — a river party-boat ride with dinner and dancing

19 AUGUST, TUESDAY

Scientific Session

Don Schaefer—Transcendental Biphysio Chemographic Energy Transmission

Saul Weiss — Photography of Unstained Immunoelectrophoresis and Immunoglobulin Precipitant Bands

Julie Langham — Photography of Biological Response to Highly Radioactive Particles

Earl Choromokos, and others — Fundus Angiography in Man Performed in Conjunction with Carotic Arteriography

Nile Root — The Third Moon of Mars

R. J. Cheale — Variable Strobe Unit for Use in Macrophotography

Idea Clinic

Nicholas Graver and Dr. Leon J. LeBeau

Official Luncheon

Presentation of RBP Certificates

Speaker: Dr. Edward H. Rynearson — Biophotography — The Profession With No Tension

Illustrated Talk

Walter G. Heun

Discussion

Gregg Orwoll — Legal Consideration in Medical Photography

Visit to Commercial Exhibits

20 AUGUST, WEDNESDAY

Review of Media of Our Profession (Symposium)

Moderator: Dr. Hal Riehle

Scientific Session (Afternoon)

Will E. Renner — Sophisticated Projection Systems Utilizing 35-mm Slides

R. F. Irvine — Audio Presentation of a Scientific Paper

Carroll M. Weiss — Crisis in Medical Educations — Solutions with Biophotography

Symposium

Solving of Practical Problems in the Production of Motion Pictures

Screening of Award-winning Motion Pictures

Social Activities

Coffee for Ladies at S. J. McComb Residence

Tour of Historic Mayowood

21 AUGUST, THURSDAY

Symposium —

Closed Circuit Television in Scientific Investigation and Education

Moderator: Lt. Col. Stephen P. Dittmann

Second Business Meeting

Eastman Kodak Cocktail Hour

Awards Banquet

Biomedical communication: a multidisciplinary approach

HERBERT R. SMITH

Medical education is only now beginning to make significant use of audio-visual techniques. Their utilization is increasing as it becomes apparent that they transmit more information more quickly than many traditional teaching methods. The lecture slide and published illustration make the spoken and written word more vivid, stimulate interest, and promote longer retention (Table 1).

Table 1 Relation of knowledge recall to method of transmission

Method of transmission	Knowledge recall	
	3 hours	3 days
Narrative	70%	10%
Visual	72%	35%
Combined	85%	65%

Two factors emphasize a critical need for improving teaching methods in medical education. In the United States, the population explosion will necessitate an increased number of doctors to maintain even our present barely adequate ratio of one doctor to 1000 people. Eleven thousand new doctors each year will be needed between this present year and 1975. Last year 7400 were graduated, and many of these were specialists.

The second factor is the knowledge explosion. Professor John Goodlad of the University of Southern California made the following statement: "If the accumulation of knowledge is plotted on a time line beginning with the birth of Christ, it is estimated that the first doubling of our knowledge took 1750 years; the second doubling of knowledge came 150 years later in 1900; the third took 50 years, in 1950; and the fourth doubling of our world's total knowledge took only ten years, in 1960." I understand that it doubled again between 1960 and 1965.

The need to transmit more knowledge to more people will require improved teaching methods. Audio-visuals, with their proven effectiveness, will play an increasingly important role in all forms of education. Therefore, the biomedical communicator must be prepared to play a larger part in the future of medical education. Our role has been a growing one for some time, but inevitable future acceleration demands that we reevaluate our present approaches. On a whole, we fall short of what we should be doing right now, and much less are we prepared to meet the future.

The value of illustration has been recognized since earliest medical history. Some of the finest examples of early Egyptian art portray medicine as it was then practiced. During the Renaissance, Leonardo da Vinci produced anatomic

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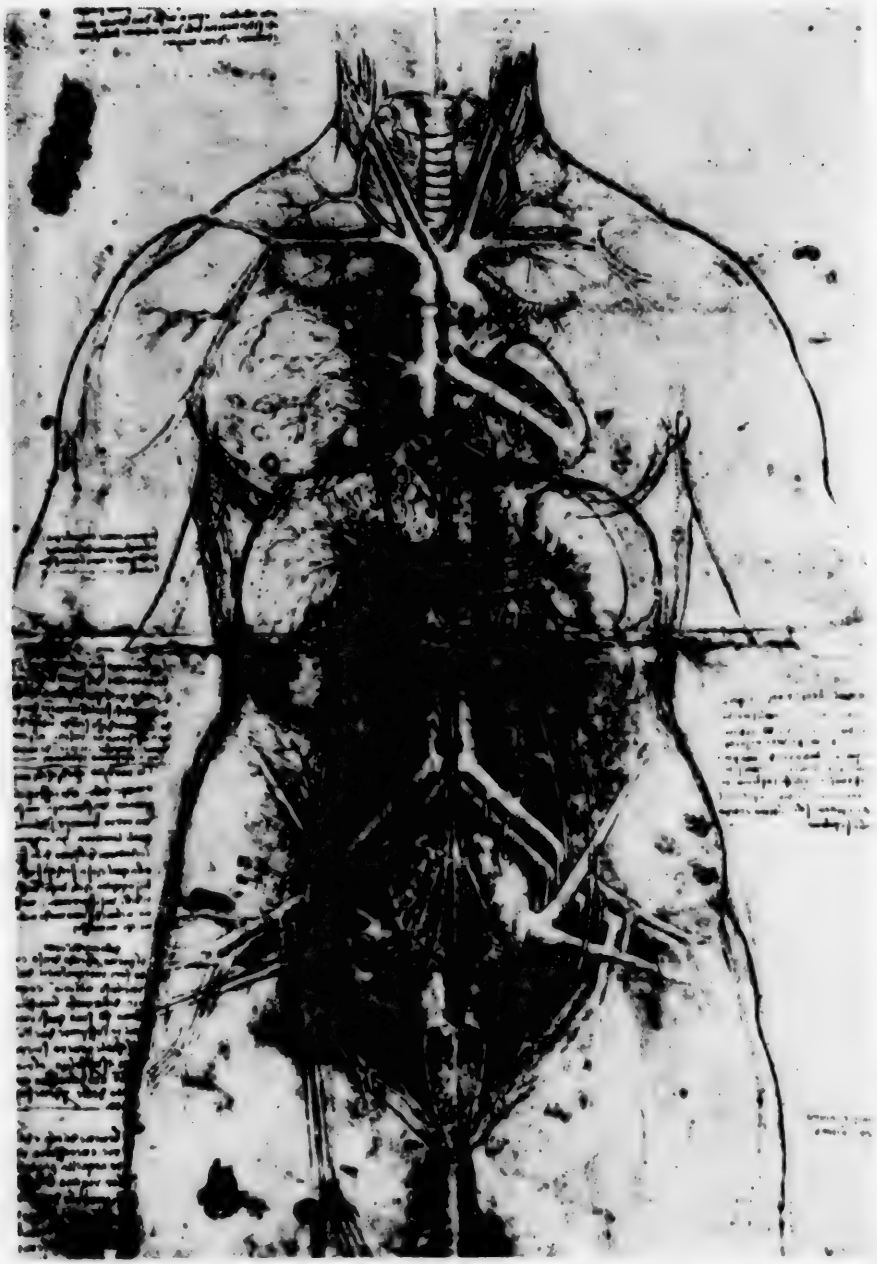

Figure 1 Leonardo da Vinci's drawing of the urogenital system from human anatomy and according to principles of the Galenical physiological system. (*From Bettmen Archives*)

drawings that were as much a contribution to early knowledge of anatomy as they were to art (Figure 1). Andreas Versalius' medical volume *De Humani Corporis Fabrica,* produced during the sixteenth century, is perhaps most famous for its drawings. Many other illustrations appear in early medical literature, but until soon after the beginning of the twentieth century medical illustration was little more than an avocation of the fine artist.

A program to produce illustrators trained in both art and the medical sciences was needed, and in 1910 Max Brödel (1870-1941) established the Department of Art as Applied to Medicine at the Johns Hopkins University School of Medicine. Students entered this new department already well grounded in art. They spent many months in the anatomy laboratory, in the autopsy room, and at the operating table to obtain the needed background. They developed drawing techniques suitable to medical illustration and acquired the scientific approach and attitude.

The philosophy that Brödel instilled in his students was as important as his drawing techniques. He insisted on seeing for himself the structures to be portrayed so that he could avoid "the perpetuation of errors" that can result from relying on another's words or drawings.

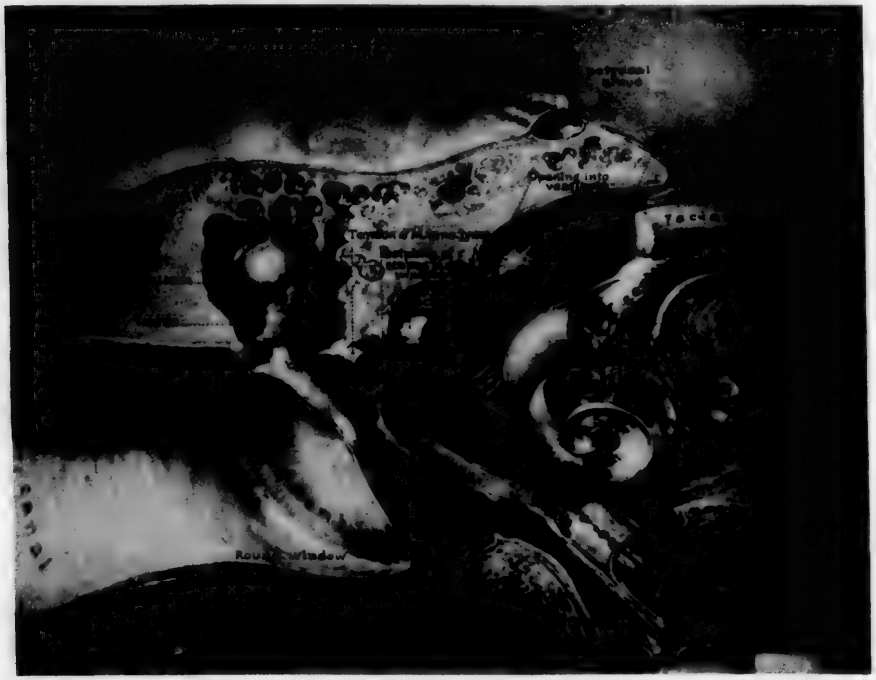

Figure 2 Max Brödel's anatomic drawing of the human ear, made after several months' careful study of wet and dry specimens at different stages of dissection and with the use of many sets of serial sections. (*Courtesy of Johns Hopkins University School of Medicine*)

An excellent example is the drawing of the human ear made after his retirement in 1940 (Figure 2).

A second outstanding school of medical illustration was established in 1921 at the University of Illinois School of Medicine by Tom Jones, whose beautiful work in wash techniques contributed new approaches to the field. These departments, with Brödel's and Jones' abil-

Figure 3 Early (1910) medical photograph of the human heart, representative of the period during which the photograph began to replace the drawing as a means of recording the appearance of pathological specimens.

ities and philosophies, directly and indirectly generated most of today's medical illustrators.

Medical photography and illustration share an early benefactor in Leonardo da Vinci, who described the principle of the early camera obscura. After the first successful daguerreotype was invented in 1837, the art and science of photography developed rapidly and, as its capabilities improved, the field of medical photography gradually became established (Figure 3).

Ironically, some medical illustrators became concerned for the future of their field, as it became apparent that the photographer could illustrate many subjects with greater accuracy and speed. Today it is obvious that the two approaches do not compete, but complement each other. The newer concept of the biomedical communicator, be he photographer, illustrator, writer, television producer, or technician, has evolved. It is only with a team approach that we will be able to meet our obligations to the future needs of medical education.

Photography is, perhaps, most often the appropriate medium of medical communication. The medical photographer can depict a given subject with almost complete accuracy (Figure 4). The photograph's authorative documentation cannot be achieved with a drawing. The medical illustrator, on the other hand, has the freedom to reconstruct and simplify his image by using information obtained from a variety of sources (Figure 5).

Subject matter and its intended use suggest the medium for a present-day teaching aid, but imagination and creativity determine the degree of success of the final presentation. Often a combination of approaches will make a point most effectively (Figure 6). A slide of

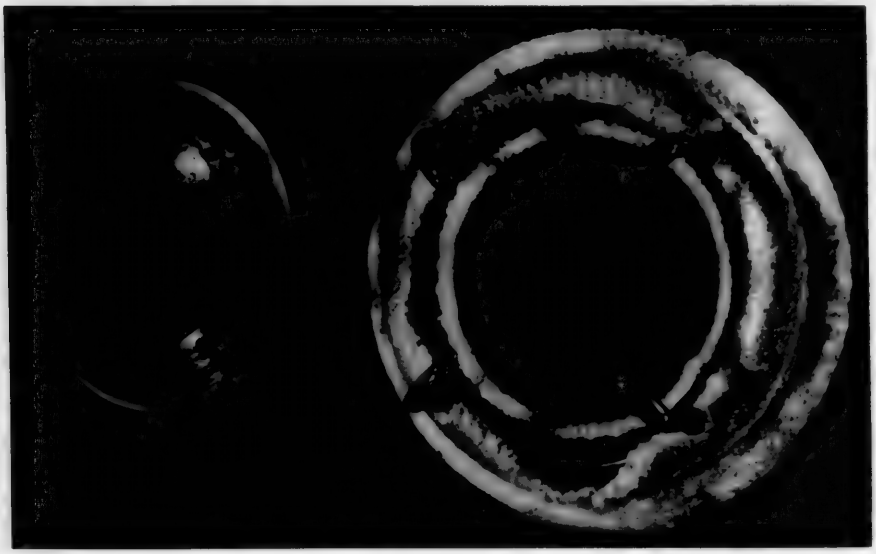

Figure 4 Photographic documentation of changes in a valve prosthesis during pulse-duplicator testing. (*Photograph by Joachim D. Zwer*)

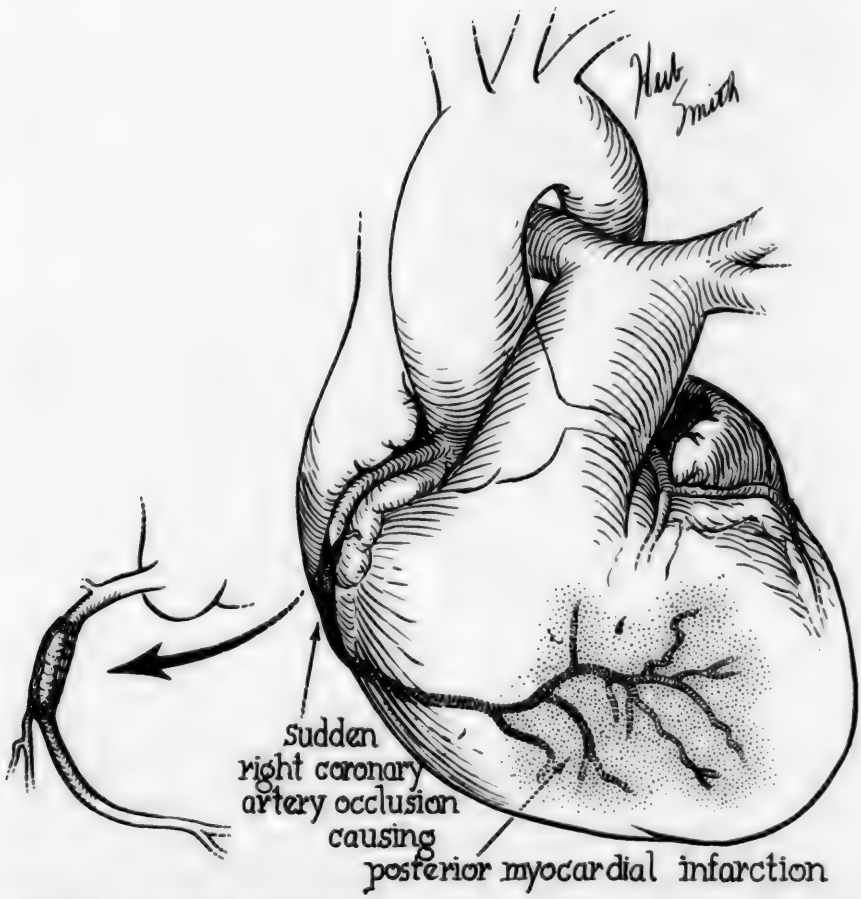

Figure 5 Drawing to illustrate surgical technique for treatment of acute coronary artery occlusion, based on preoperative angiographic studies, observation at surgery, and the medical illustrator's knowledge of anatomy.

artwork utilizes photography when it is converted to a projectual, and imagination and technical ability on the part of the photographer can make a big difference to the final result. Black-and-white line drawings, while most suitable for publication, do not always make the best projectuals. Color, with its visual impact, can be added by the use of filters, or a film positive can be made and back-painted very quickly and easily to result in a full-color slide. Conversely, if suitable colors are used, a slide can also be photographed in black and white for reproduction. In our medical communication unit we feel that color is usually more effective in a slide, and we sometimes do work both in black and white and in color for maximum impact in each presentation. Consequently, we

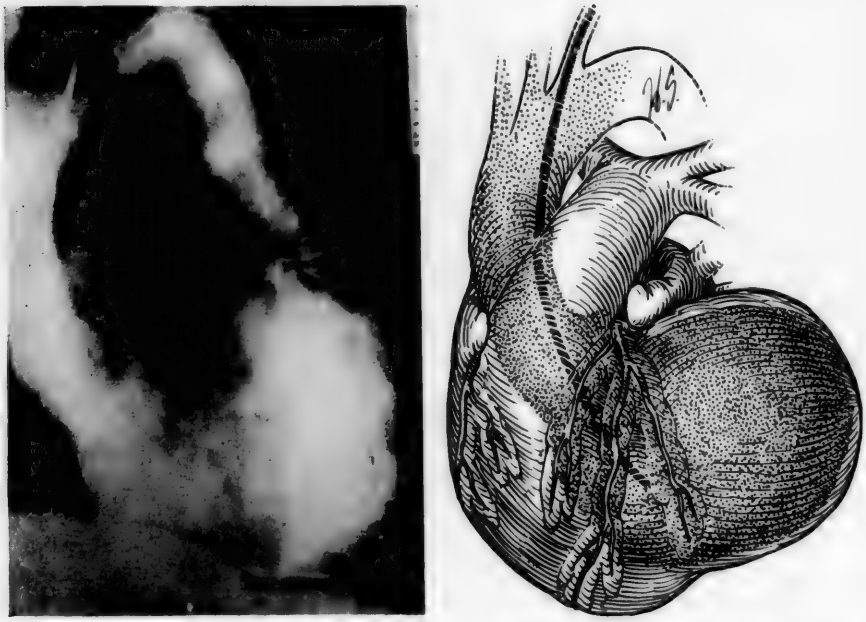

Figure 6 *Left*, angiographic study of ventricular aneurysm: *right*, diagrammatic drawing to clarify the angiogram.

continually try to develop techniques that are fast and effective. In addition to using the backpainted film positive already mentioned, we often use drawings on acetate cels. The outline is inked onto the front surface, often being traced from a pencil sketch for a fully rendered drawing for publication. The inked cel is then turned over and backpainted to produce not only color art but also a bold simplified image, which is more suitable for slide projection.

Charts and graphs are generally done so that they can be photographed in color and high-contrast black and white. An electric typewriter with large type used with Color Vu papers has proved to be fast and effective. These papers produce clean, black, typed copy and they are available in a wide range of colors. The addition of colored tapes, colored acetate overlays, and press-on letters can add variety to this technique and produce attractive slides very quickly.

When possible, statistical data should be presented in graphic form, such as a line, bar or pie graph. As a further step, appropriate artwork may be used to give the slide more impact.

If I seem to have placed a great deal of emphasis on the slide, it is only because I believe that most slides shown at medical meetings are poor. I have heard audiences moan and grumble, and I have seen people fall asleep or even walk out from a presentation that was accompanied by illegible or dull projectuals. We as communicators must be concerned about every type of visual presentation.

The scientific exhibit should communicate its information concisely and simply (Figure 7). The cluttered exhibit repels viewers because it demands of a person too much time wading through an excess of disorganized material. In addition to planning sessions in which scale models are used to work out the design problems, two means are helpful in reaching desired simplicity. The first is the hand-out brochure, which contains more detailed information than the exhibit presents. Often this is the lever needed to enable the exhibitor to eliminate excessive material from the exhibit. These brochures are picked up and taken home, where sufficient time can be spent studying the material and there is no competition from the exhibit hall.

A second way to simplify an exhibit is to use the silk-screen process to apply copy and artwork to the panel (Figure 7). This technique allows application of any copy, line art, or screened halftone to the panel in any color desired. The result is a clean, neat panel that usually appears less cluttered than it is in reality. The same line artwork produced for the silk screen can be used in the brochure and in other publications.

The ideal to strive for in both exhibit and brochure is maximum graphic presentation with minimum copy. Both art and photography should be used extensively, and both with a degree of creativity. Medical subject matter does not necessarily dictate a visually dull approach. Members of the scientific professions are exposed to sophisticated commercial presentation every day, and we must compete for their attention.

The medical teaching film is another area in which there is room for improvement. Many such films fall short because of poor cinematography or simply failure to position the camera properly. However, most suffer from poor editing, lack of explanatory or orientation diagrams, and generally inadequate effort at coordination of visual and narrative components. This is particularly true of films produced within an institution, and yet these films can be very successful and still economically feasible with little extra effort. We as communicators need to become more involved with the film as a total unit.

Figure 7 Scientific exhibit with copy and artwork applied by the silk-screen process.

Many of these comments could apply to successful television presentation. Whatever the medium, the biomedical communicator has an obligation. He must familiarize himself with the subject matter to the degree that he can suggest possible improvements in the presentation. The investigator or teacher will know his material, but he is not trained and experienced in the best methods for communicating his information. Undoubtedly, the future will bring an increased demand for the biomedical communicator, and this is welcomed; but we need to be on our guard. Right now, far too many drawings and photographs that are used in all types of presentation are of poor quality. My criticism is not so much from the standpoint of aesthetics and technique as from the more important standpoint of lack of communication. These drawings and photographs neither make the point nor tell the story.

Ours must be a role of maintaining a standard of excellence in biomedical communications. The BPA certification and AMI school accreditation programs are important steps in this direction. Beyond this, we as individuals must strive to see that high standards are upheld within our own departments. An elevated individual standard and closer cooperation between the various disciplines will enable us to meet the challenge of the future. The 1970 combined meeting of the Biological Photographic Association and the Association of Medical Illustrators with participation by the Council on Medical Television will make a significant contribution toward this end.

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Journal of the Biological Photographic Association Vol. 37 No. 3 July 1969 143

A new photomicrography attachment with a semiautomatic exposure meter and control

FRITZ GABLER and KARL KROPP

Except for photomicroscopes, most instruments used for taking photomicrographs are camera attachments, which are mounted on top of the ocular of the microscope in the parallel path of rays. Several such attachments are on the market. It seemed to us that a camera system with a semiautomatic exposure meter and control was needed, and that such a system had to incorporate the following features:

- capacity to take all standard film sizes
- a single reflex housing to fit all still- and motion-picture cameras
- a viewing telescope, which could be used during exposure
- capacity to accept many standard oculars
- a completely vibration-free shutter, which would permit exposures from at least 1/125 sec to very long periods
- a reliable exposure meter, calibrated to show required exposure times
- a registration device for projecting numbers, signs, and other marks onto the film frame
- reduction in the number of mechanical adjustments and manipulations needed to ensure maximum operating ease, dependability, and versatility.

An analysis of these desirable features showed that intricate incorporation of electronic, optical, and mechanical components was demanded.

ABOUT THE AUTHORS

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Reflex housing

The main element is a reflex housing (Figure 1). It can be attached to the upright tube of any type of microscope. After the eyepiece is inserted in the tube, it is secured to the reflex housing by a locking screw. An adapter on

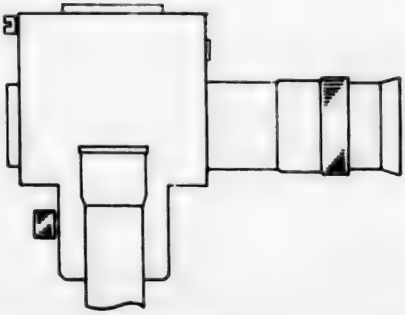

Figure 1 Reflex housing.

top of the housing permits use of any film, 35 mm to 3¼ × 4¼ inches, including Polaroid film. Objectives may be adjusted to infinity. At the right side of the reflex housing is an attached focusing telescope. The same reflex housing is also suitable for use with motion-picture cameras.

Beam splitter

Inside the reflex housing, a beam splitter is fitted on a slide. In its normal position, 20% of the light is directed through the telescope to the observer and 80% to the film (Figure 2). This large amount of light makes short exposure times possible. However, the image seen through the telescope is normally bright enough for easy focusing and observation, not only before but during photographing. If the image intensity happens to be too low for viewing and focusing, it can be improved by inserting a mirror into the reflex housing. The mirror reflects 100% of the light to the observer (Figure 3). To prevent the taking of a photograph when no light reaches the film, the photomechanism is electrically locked until the mirror is withdrawn. As the viewing telescope has a magnifying factor of ×1.6, exact focusing is possible at even low magnifications. To compensate for vision differences, provision is made for a correction of ±5 diopters. A gray filter (Figure 4, *arrow*) can be swung in and out to control brightness of the telescope image and to exclude extraneous light during prolonged exposures.

In the viewing telescope the outlines of picture sizes such as 35 mm, 6.5 × 9 cm, and 3¼ × 4¼ inches are visible, and a twin-line circle (Figure 5) aids sharp focusing.

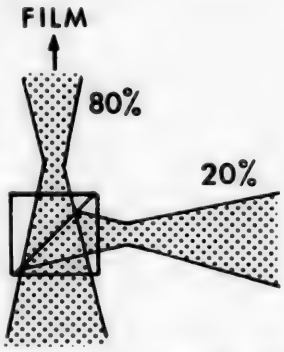

Figure 2 Paths of light through beam splitter.

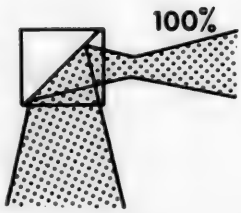

Figure 3 Reflection of light from mirror in beam splitter.

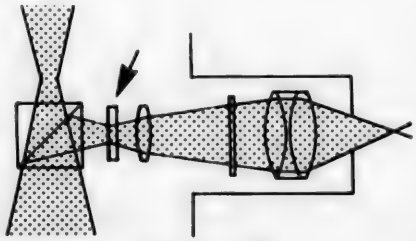

Figure 4 Viewing telescope.

Exposure meter

The electric shutter and the exposure meter are fitted above the beam splitter. For photomicrography, the electric shutter has been specially adapted to the path of rays. It consists of a magnetic-core motor with an iron-free anchor, on the axis of which an arm with a mirror and an opaque plate (Figure 6) are fixed. This plate, and the funnel-like aperture that is located above it, constitute the actual shutter. When the exposure button is pressed, the motor swings the arm out from its resting position, thereby opening the aperture and permitting the rays to pass towards the camera. At the end of the exposure time, voltage is interrupted, and a spring returns the arm to its resting position and closes the aperture. Because of their favorable position in the exit pupil of the microscope, the small moveable parts are free from vibration at any exposure time down to a minimum of 1/125 sec.

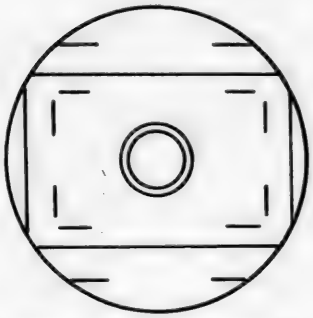

Figure 5 Twin-line circle in the viewing telescope.

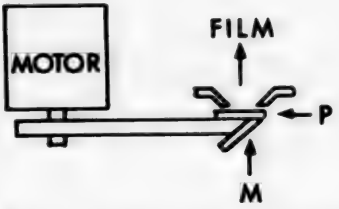

Figure 6 Motor and arm attachments, including M, mirror, and P, opaque plate.

Mirror

The mirror, a part of the special shutter, is an important feature. In its resting position, when the film is not being exposed, the mirror directs all the light through a lens to the light detector, a cadmium-sulfide photoresistor (Figure 7), which serves as a light-measuring device. Because all the light is engaged, the sensitivity of the instrument has been increased to such an extent that exposure times up to 1 hour are possible and an image of very low light intensity can be measured and photographed.

To facilitate light measurements both before and during exposure, when the shutter swings the mirror out of the path of rays, a small glass plate (Figure 8, *arrow*) in front of the shutter con-

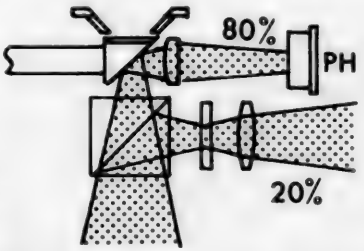

Figure 7 Path of rays for measuring light, showing (*PH*) photoresistor.

tinues to reflect 8% of the light to the light detector. This feature, which makes it possible to measure and control the exposure time during photographing, is of special interest for cinephotomicrography.

For a motion-picture camera, a light trap may be mounted on top of the reflex housing and objectives may be dipped in without actually touching the trap. To avoid vibration, the camera itself is not brought into contact with the microscope but fastened to a separate support, such as a wall bracket (Figure 9). Cinecameras do not require the previously described shutter. Exposure times are regulated by the speed in frames per second, and by sector aperture. Short exposure times of motion-picture cameras need strong light sources. The small amount of light (8%) diverted by the glass plate to the light meter is sufficient to establish correct exposure times. The electric shutter in the reflex housing remains open when motion pictures are being taken.

Measurement and control of exposure time are made by a control unit, which makes contact with the reflex housing by a multiple-core cable. Its electrical principle is shown in Figure 10.

When the photo device is at rest, 80% of the light falls on the photoresistor, which is arranged on a bridge circuit that has a transistorized linearizing component. Through a series of transistors this component is adapted to the characteristic curve of the photoresistor. The resistors are controlled by a rotary switch, and the current, determined by the photoresistor for any given illumination, is balanced by the linearizing component. A transistorized amplifier measures and amplifies the bridge current. The measured values are converted into plus-minus recordings on a zerometer with light signal.

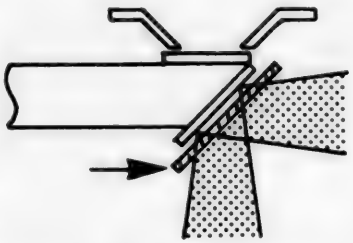

Figure 8 Path of rays, showing (*arrow*) plate in front of shutter.

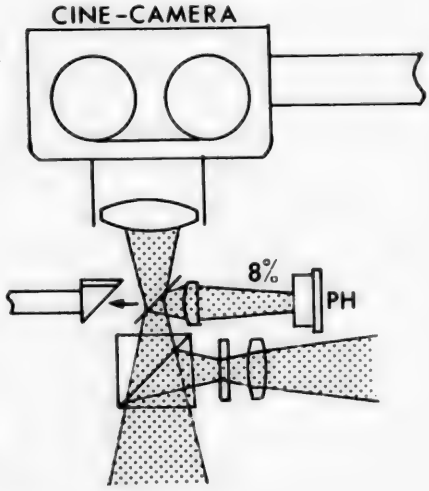

Figure 9 Position of cinecamera.

Exposure-time and DIN-ASA scales

The control unit also includes a multivibrator that serves as a timer. Its timing resistor-capacitor combinations are arranged to produce the geometrical exposure series comprising the following values: 1/125, 1/60, 1/30, 1/15, 1/8, 1/4, 1/2, 1, 2 sec, up to 1 hour.

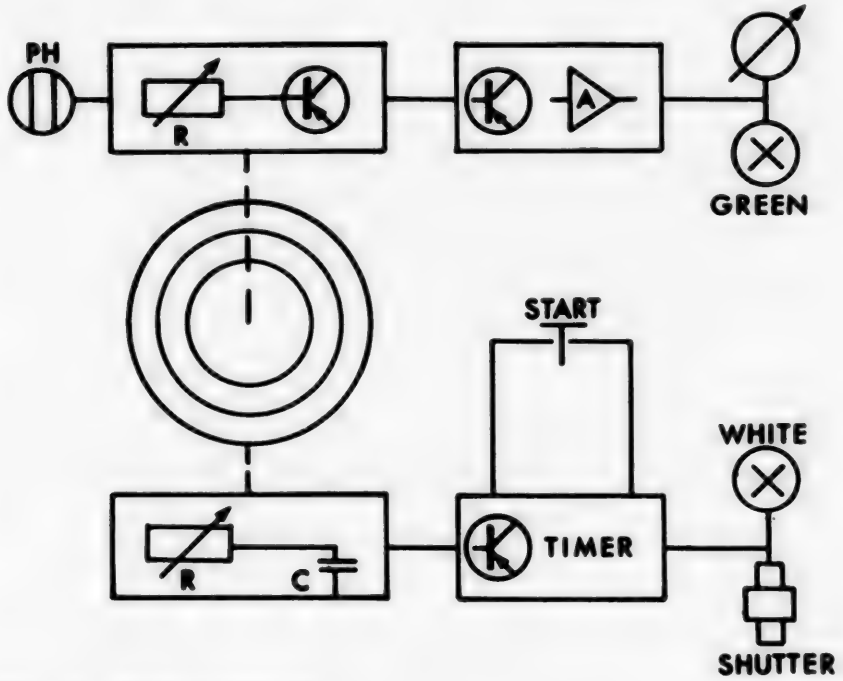

Figure 10 Wiring of control unit.

These combinations are actuated by a second rotary switch, whose control knob carries a combined exposure-time scale and DIN-ASA scale (Figure 11) for the film speed. The scale is mounted on the same shaft as the knob for the switch of the linearizing component resistors. Both knobs are mechanically interconnected by a coupling, but they can be decoupled for setting the film speed. The outer circle (Figure 11 *A*) of the knob carries the exposure time and the DIN-ASA scale. The inner one (Figure 11 *I*), independent of *A*, moves by simple axial pressure directed against a spring. Part *I* carries the index numbers, which depend on the size of film used or the projection distance. For example, in Figure 11,

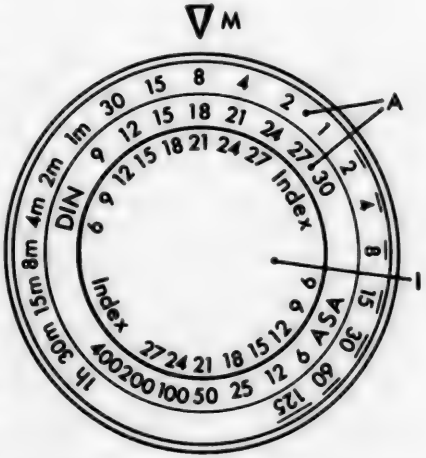

Figure 11 Exposure-time and DIN-ASA scales.

for a 35-mm camera mounted on the reflex housing, if a film of 100 ASA (21 DIN) is used, Index 24 (on the inner circle *I*) is set against ASA 100 (on outer circle *A*). A basic calibration is thus obtained. The outer circle, together with *I*, is then rotated until the green light signal of the zerometer shows that the bridge is matched. The now correctly fixed exposure time is opposite the mark *M*, which in Figure 11 is at 8 sec. The shutter timer can now be activated with the exposure button. The timer opens the shutter for the duration of the established exposure time and a white signal lights up. After the shutter closes, the film has to be transported by hand.

The double knob, then, serves the following functions: computation of

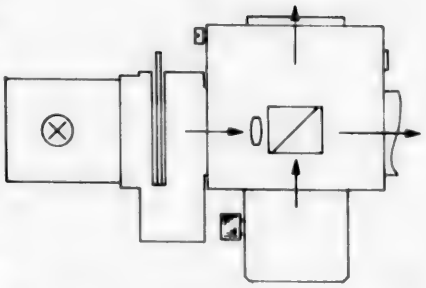

Figure 12 Registration device on reflex housing.

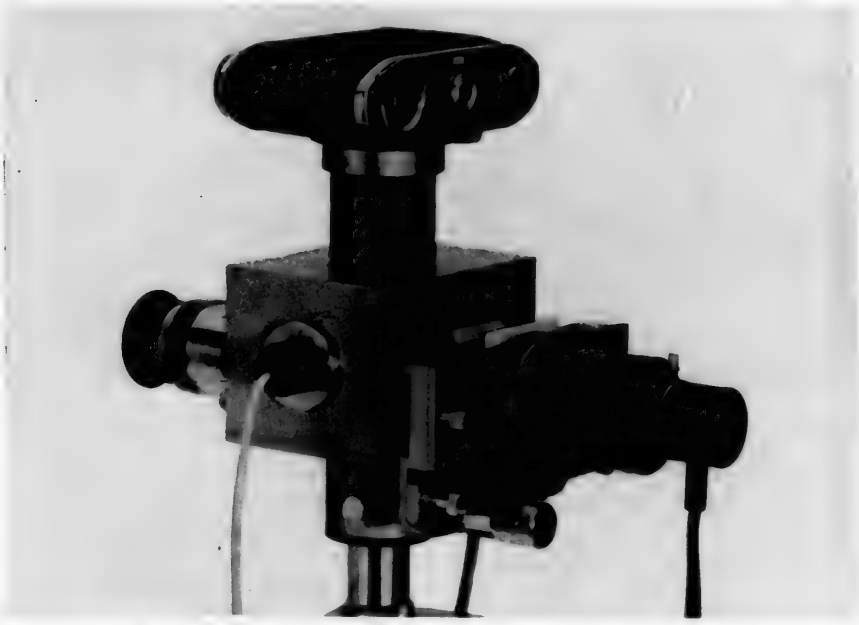

Figure 13 Photomicrography attachment with (*rear*) focusing magnifier, (*front*) device for projecting numbers and other marks onto film, and (*top*) a 35-mm camera.

Figure 14 Control unit, showing exposure-time indicator; on, time, and stop buttons; and the exposure-time and DIN-ASA scales.

correct exposure time for each combination of projection distance (index), film speed, image brightness, and visual indication of this exposure time. The photo cell of the exposure meter is not built into the reflex housing, but mounted on a plug. Therefore, it can be taken out and used for exposure-measurement on any other part of the microscope, for example, on the ground glass of a large sheet-film camera. It is also possible to project numbers and other marks onto the film by using a registration device (Figure 12). This device, containing an adjustable film stage and projection optics, is fastened to the reflex housing and its control unit (Figures 13 and 14). Slides or drawings with numbers and other marks can be set into the film stage. They are imaged by the beam splitter into the still or motion-picture camera and can be directed to project to any place on the film. At the same time, these signs are visible and can be orientated through the telescope.

Received 23 January 1969

Photography in bird control for air safety

VICTOR E. F. SOLMAN

In 1962 the problem of bird damage to aircraft had become so serious that the National Research Council of Canada was asked to investigate and make recommendations. The Associate Committee on Bird Hazards to Aircraft was formed to review the problem and direct research. The Committee included representatives from the National Research Council, the Departments of Transport and National Defence, the major airlines, the aircraft manufacturers, the Canadian Airline Pilots Association, and the Canadian Wildlife Service.

The initial review of the problem revealed that birds visit airports for a number of reasons and that they can be discouraged if the attractions are removed or greatly reduced. That problem was clearly biological. The representatives of the Canadian Wildlife Service studied more than 70 airports to define the problem and to recommend solutions. The solutions were neither easy nor cheap, and often involved major changes in the airport environment to make it unattractive to birds.

Even when most of the obvious bird attractions had been removed, there were occasional visits by birds. Those birds had to be driven off by emergency methods. Ways that were tried ranged from playing records of bird alarm calls through the use of mechanical scaring devices to the use of trained falcons. All the methods tried were useful in certain conditions, but none were entirely satisfactory in all conditions. The single most important factor in getting rid of birds was human motivation: the determination on the part of the persons exercising the control to remove birds before they caused damage. One of the most effective scaring devices was, and still is, the careful use of exploding shotgun shells to break up concentrations of birds and drive them away.

It was realized from the beginning that birds caused two problems for aircraft operators. The first problem involved the danger birds pose to aircraft moving on the airport, preparing to land, and taking off. For example, an Electra taking off from Boston Airport in 1960 crashed after striking a flock of starlings. Sixty-one people were killed, and eleven more were injured.

The other problem involved areas away from the airport, particularly during the time of migration, when large numbers of birds travel to and from their breeding grounds. In a typical autumn, 75 million ducks, 5 million geese, 350 thousand cranes, 100 thousand swans

ABOUT THE AUTHOR

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and much larger numbers of small birds move south across the transcontinental airways. Many of these migrate at night, when visual observation is difficult or impossible. The seriousness of that problem was shown when a Viscount aircraft collided with two whistling swans while flying more than 5000 feet above the ground in the autumn of 1962. The aircraft was severely damaged and crashed with the loss of 17 lives. Clearly there was a need for a way to study bird migration to learn of the bird traffic at various times and places and to work out methods by which aircraft could avoid those areas.

It had been known since World War II that birds could be detected by radar. It was desirable to study bird migration by using that method to the best advantage. Initial studies made by direct viewing of the presentation of a plan-position radarscope indicated the difficulty of working by that method. Photography of the radarscope overcame the difficulty of live observation, simplified the making of observations, and provided a permanent record for later study. The image of a radarscope can be made sufficiently bright for it to be photographed with a conventional still camera on black-and-white film by using lenses of moderate speed.

The radar used for airway traffic control presents an image of an area surrounding the radar antenna. The antenna rotates and picks up echoes from objects in all directions in a circle of which the radius may extend as much as a hundred miles from the airport. A new image is created at frequent intervals, customarily every 10 seconds. Echoes from high-speed aircraft move perceptibly between succeeding echoes shown on the radar beam. If a time exposure is made, the echoes recorded

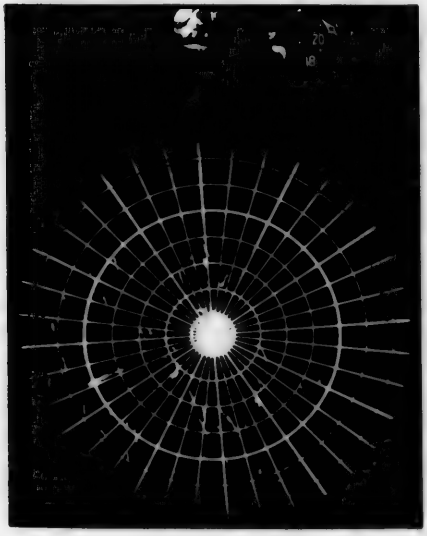

Figure 1 Time exposure of radar screen, showing a few bird echoes.

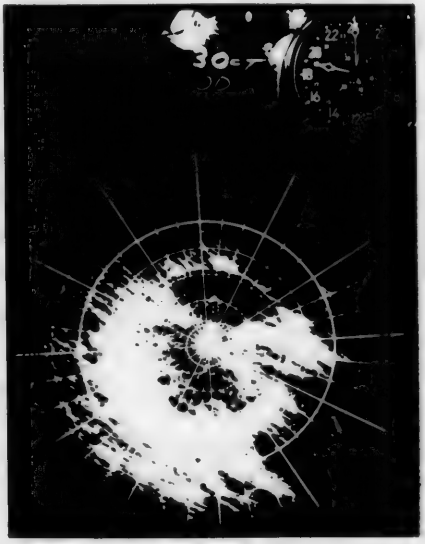

Figure 2 Time exposure of radar screen, showing a moderate number of echoes and indication of southeastward flight.

on each successive sweep produce a line echo on the photograph. The line extends in the direction of movement and its length indicates the speed of movement. The same technique can record echoes of birds, but because of their relatively slow speed, the exposure must be longer to show movement. If a camera is mounted to photograph the radar screen so that time exposures can be taken as needed, and a clock and calendar are included in the picture, a permanent record is available of the radar presentation of the bird echo occurrence (Figures 1 to 3).

To obtain useful information on bird presence, the exposure may need to be as long as 10 minutes. It is usually desirable to know the direction of movement of the birds. That can be indicated by making a 10-minute time exposure followed after 2 minutes by a further 2-minute exposure. The result is a line followed by a dot for each bird echo, the dot indicating the direction of movement of the birds that give the line echoes. Each bird or group of birds appear as a line in the 10-mm time exposure.

Although the still-camera time-exposure technique provides useful information and can provide it very quickly through the use of a Polaroid camera, it was soon found that time-lapse motion pictures were far better for revealing the complexity of the movement.

The motion picture cameras that were selected needed to provide single-frame exposures for each sweep of the radar, then allow a short period in which the shutter was closed and the film advanced. A suitable electronic intervalometer was devised to actuate the camera automatically, so that a technician was needed only once or twice a day to reload the camera with film or maintain the equipment. Figures 4 and 5 show the camera and other equipment.

Figure 3 Time exposure of radar screen, showing a very large number of echoes.

When the films are projected at normal projection speed, the time is compressed by a factor of 240. This makes it possible to review quickly large amounts of study film taken from a group of radar sets scattered across the continent.

The use of a motion picture camera to take very large numbers of single-frame exposures at 10-second intervals for periods of as long as 12 months imposes a severe strain on the camera mechanism. To project the films at normal speed without irregularity, it is desirable to have a camera in which film registration is very exact during exposure. The most suitable equipment is quite expensive, and we have not yet found a camera that will provide the desired service for long periods without maintenance. Some cameras, even though expensive, have components that break down

quickly under the successive shocks of single-frame operation. To secure reasonably dependable observation, it was necessary to rebuild the drive mechanisms in several cameras by using stronger-than-standard materials for gears and other components.

The film can be studied either as a negative or as a positive, depending on the preference of the worker. The cost of direct reversal positive film is somewhat higher than that of negative film.

The films show the changing patterns of bird movement very well and dramatize certain aspects of bird movement, especially dispersal from roosting concentrations.

In order to analyze the very large quantities of data that have been collected during the study period, pertinent data from the film record on each bird occurrence are coded for computer input. The data can then be correlated with weather data from the local areas concerned, as well as from the areas from which the bird movement has come. The relation of weather to bird movement is complex, but it has been possible to

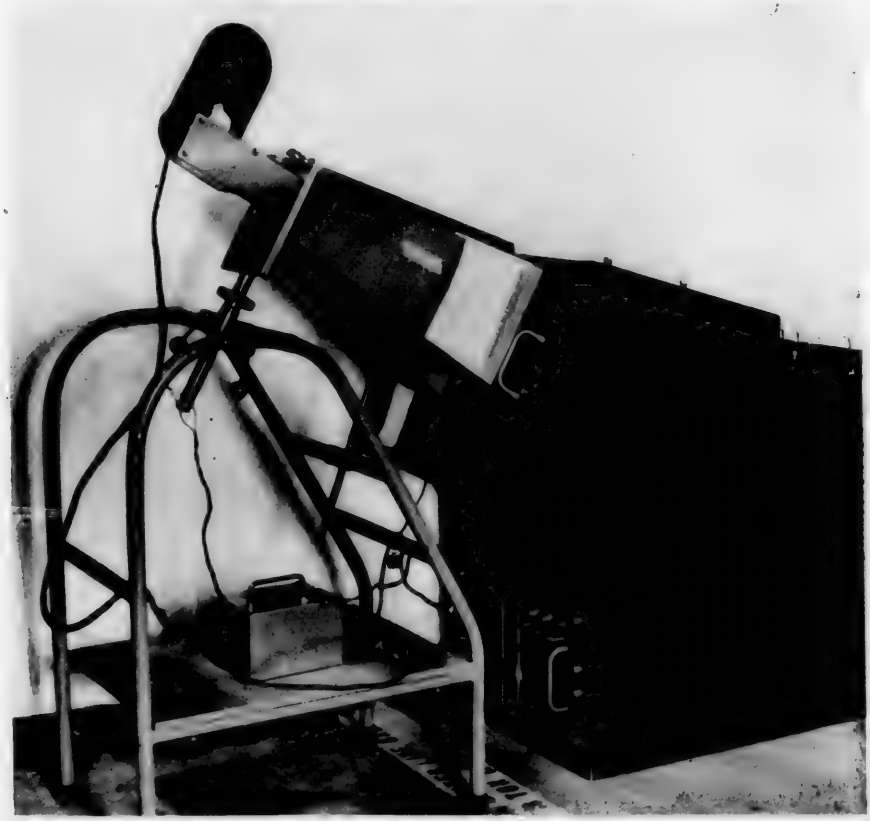

Figure 4 A Vinten 16-mm camera of 200-ft. capacity mounted on an adjustable stand and fitted with a light shield.

Figure 5 Cinecamera and light shield positioned in front of radar display console. The clock can be seen through the open door of the shield.

find good correlations between certain autumn weather patterns and the autumn migration of waterfowl that occurs at that time. There are equally good correlations for the spring migration of some important species. Local bird movements studied by the same technique are usually more closely related to daily environmental cycles, which shift gradually as the seasons change.

Once the correlations between bird migration and weather are known, it is possible to forecast bird migration in relation to weather forecasts. Experimental forecasts of bird migration have been made and have been used to adjust training programs in flying. The accuracy of those forecasts can be, and has been, checked against radar observations and photographs taken during the valid period of the forecast.

We have still a long way to go to achieve the level of accuracy needed for use of bird hazard forecasts in aircraft traffic control programs. Our aim is to enable aircraft operators to avoid concentrations of migratory birds in the way they presently avoid hazards such as thunderstorms. We have not lost any military aircraft because of thunderstorms for the past several years. We have lost at least seven military aircraft through bird collision in the last 4 years. As our methods of forecasting the location, duration, and intensity of bird hazards improve, damage and loss of aircraft will decline. Without the presently available photographic techniques for

recording the radar data, we would not be able to study the problem as we have, nor could we have demonstrated it to the agencies who need the information to improve safety of aircraft operation.

Related Publications

Gunn, W. W. H., and V. E. F. Solman. 1968. A bird-warning system for aircraft in flight, p. 87-96, 106-116. *In* The problems of birds as pests. Edited by R. K. Murton and E. N. Wright. Academic Press, London, England.

Munro, D. A., and R. D. Harris. 1963. Du danger que constituent les oiseaux près des aérodromes du Canada (Some aspects of the bird hazard at Canadian airports), p. 173-206. *In* Colloque sur le problème des oiseaux sur les aérodromes (Symposium on the problem of birds on airports). Edited by René E. Busnel and Jacques Giban. Institut National de la Recherche Agronomique, Paris.

Solman, V. E. F. 1966. The ecological control of bird hazards to aircraft. Proceedings of the Third Bird Control Seminar, Bowling Green State University, Bowling Green, Ohio, September 13, 1966. p. 38-52.

Solman, V. E. F. 1968. Bird control and air safety. Transactions of the Thirty-third North American Wildlife Conference, Wildlife Management Institute, Washington, D.C. p. 328-336.

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Erythrocyte photomicrography: contrast control by monochromatic transillumination

WILTZ W. WAGNER, JR, PAULA D. BRINKMAN, D. BOYD BAKER, and GILES F. FILLEY

The color of blood in large samples becomes progressively less intense as the sample is diluted either by adding diluent or by "optical" dilution, that is, by increasing optical magnification of a monocellular layer. When a single erythrocyte is viewed microscopically with white light, the contrast between the nearly transparent cell and the background illumination is very low; the cell absorbs only 15% of the incident light when illuminated at a color temperature of 3200°K (*see* Appendix). Indeed, visibility of the cell image depends more on diffraction and refraction of the light outlining its borders than on light being absorbed by the hemoglobin within the cell. When circulating blood is observed in vivo, the problems of visualizing the cells distinctly are compounded by cell movement and by the observer's necessity to look through the vessel wall and perivascular tissue.

Because hemoglobin selectively absorbs certain colors, visualization of erythrocytes can be significantly improved by illuminating the cells with monochromatic light of wavelengths corresponding to the hemoglobin absorption bands, thus increasing contrast of the cell to the background. The spectral emission of various microscope light sources and the light absorption characteristics of hemoglobin are discussed in this paper in relation to practical control of unstained red blood cell photomicrographic contrast.

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Hemoglobin absorption spectrum

From the red color of blood, it would be predicted from emission and absorption color relationships that the maximum contrast would be achieved by placing a green filter in the light beam (Eastman Kodak Company, 1966, p.

51). The absorption spectrum of hemoglobin, however, is more complex than that of a simple hue. Characteristically, it absorbs very strongly in the violet and less strongly in the yellow and green (Figure 1). The quantity of light absorbed by hemoglobin as it is diluted or made thinner, changes exponentially according to the Beer-Lambert law. In these studies we have used human blood, but the results are applicable to mammalian hemoglobins in general.

From the curves in Figure 1 it can be seen that yellow (575 mμ) and green (540 mμ) are absorbed nearly equally and would be only moderately effective in increasing contrast compared to the highly absorbed violet. In Table 1 numerical absorption values for violet, green, and red are compared for the range of microcirculatory vessel sizes.

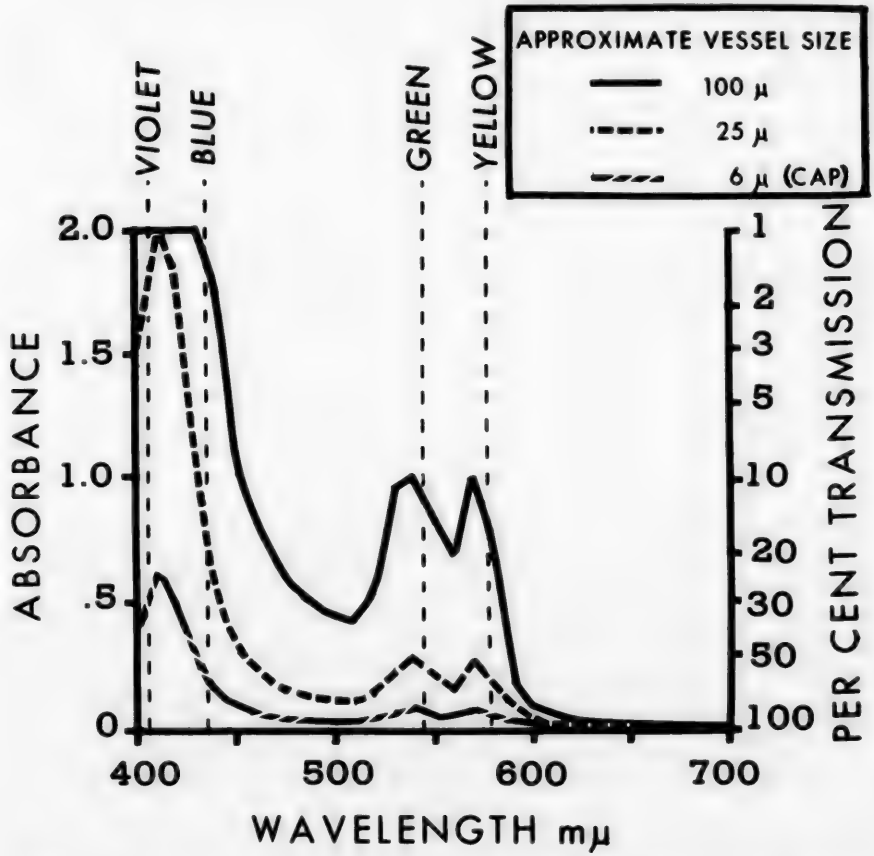

Figure 1 Microcirculatory hemoglobin absorption spectrum. Note the logarithmic character of transmission. Vertical broken lines indicate location of mercury lines.

Microscope light sources

The relative spectral brightness throughout the visible and near infrared of the three most common photomicrographic light sources, tungsten, xenon, and mercury, are compared in Figure 2. The characteristic spectrum of the mercury lamp is of particular interest, because three of its four visible lines, here broadened to spikes because of the high vapor pressure within the lamp, fall within the hemoglobin absorption bands. The precise location of the lines in relation to the hemoglobin spectrum is shown by the broken vertical lines in Figure 1.

TABLE 1 Light absorption at three wavelengths in the microcirculation

Vessel size	Violet λ= 414 mμ	Green λ= 545 mμ	Red λ= 625 mμ
100 μ	>99%	92%	6%
25 μ	>99%	48%	3%
6 μ	77%	15%	<1%

The relative brightnesses within the hemoglobin absorption bands are presented in practical photomicrographic terms in Table 2, where the exposure time with a tungsten lamp has been assigned a value of 1 second at each wavelength. The exposure times for the

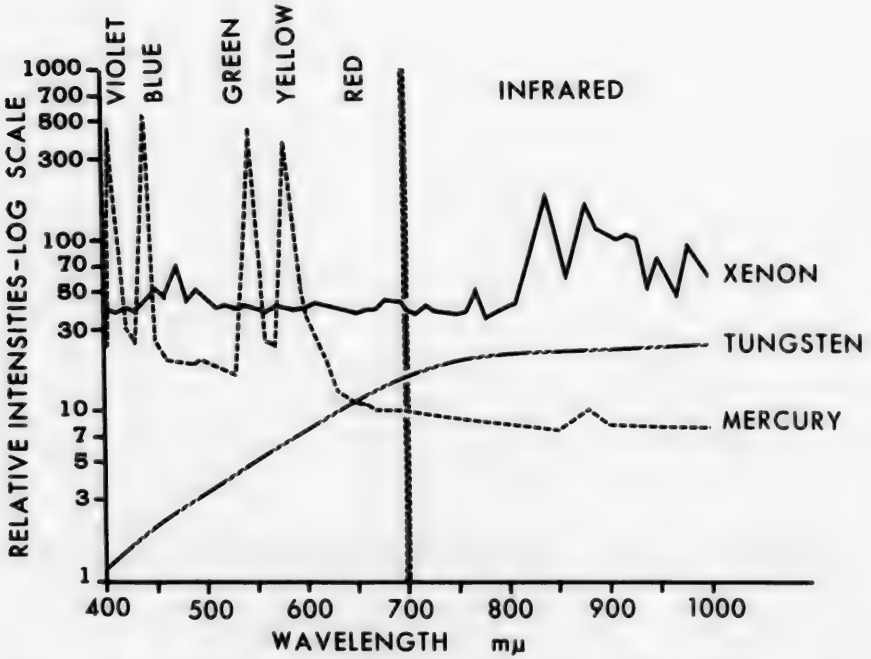

Figure 2 Spectrograms of 500-watt xenon (5500° K), mercury, and tungsten (3200° K) lamps. Broken vertical line at 700 mμ separates visible and infrared. It should be noted that many panchromatic films cut off at about 650 mμ.

TABLE 2 Relative exposure times at the mercury lines that produce erythrocyte contrast enhancement

Color and wavelength	Tungsten* 3200° K	Xenon* 5500° K	Mercury*
Violet 404.7 mμ	1 sec.	1/30 sec.	1/375 sec.
Green 546.1 mμ	1 sec.	1/8 sec.	1/100 sec.
Yellow 578.0 mμ	1 sec.	1/6 sec.	1/60 sec.

*500-watt lamp

xenon and mercury lamps indicate how much brighter than the tungsten lamp these lamps are at each wavelength.

The mercury lamp becomes an even more attractive choice for high-contrast erythrocyte photomicrography, because: its infrared radiation is relatively low, the short wavelength of the violet line increases the effective resolving power of the photomicrographic system (Klosevych, 1964), and the monochromatic character of a single mercury line overcomes chromatic aberration, although the extent of the improvement depends on the correction of the objective.

Photomicrography

Although the mercury violet line (404.7 mμ) does not lie at the peak of the violet hemoglobin absorption band (414 mμ), it is still within the region of high absorption (Figure 1) and produces high magnification photomicrographs of excellent contrast (Figure 3). However, very high absorption is not always desirable. Some transmission through arterioles and venules ($\leq 100\ \mu$) is often required in microcirculatory studies. This is illustrated in Figure 4, where the same area of an everted hamster cheek pouch has been photomicrographed at various wavelengths. With the violet mercury line ($\lambda = 404.7$ mμ), the rich capillary net can be clearly seen, but there is no penetration of the larger vessels. Capillaries are more difficult to see with the mercury green line ($\lambda = 546.1$ mμ), and when red light ($\lambda = 625$ mμ) is used, the capillaries are invisible but detail within larger vessels can be seen.

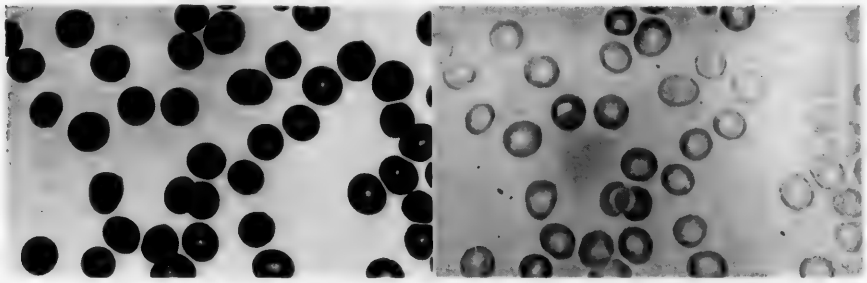

Figure 3 Photomicrographs of human erythrocytes in vitro: *left*, 404.7 mμ (violet); *right*, 578.0 mμ (yellow). Both exposures were made on a single roll of film and printed on identical paper. Even though 578 mμ is absorbed by hemoglobin, "optical" dilution reduced contrast. So little light was absorbed by the cells at wavelengths >600 mμ that it was impossible to focus the cells on the ground glass of the camera. About × 600.

404.7 mμ
Mercury
546.1 mμ
3400 K
625 mμ
3200 K

TABLE 3 Absorption data for 6 μ hemoglobin sample

Light source	Portion of visible spectrum employed	Visual color	Percentage absorption
Tungsten	Total	(White) 3200° K	15
Xenon arc	Total	(White) 5500° K	20
Mercury arc	Total	Blue-green	26
Mercury arc	Narrow band Peak $\lambda = 404.7$ mμ	Violet	70
Mercury arc	Narrow band Peak $\lambda = 546.7$ mμ	Green	15
Tungsten	Narrow band Peak $\lambda = 625.0$ mμ	Red	<1

For comparison, photomicrographs were taken with the unfiltered sources. Differences between the tungsten (3200°K) and xenon (5500°K) sources are subtle, but, as would be expected, the tungsten source, being relatively rich in red, shows less capillary detail but slightly more large-vessel penetration. The characteristic blue-green color of the unfiltered mercury source is more strongly absorbed by the hemoglobin and produces contrast exceeded only by that of the violet line (Table 3). The mercury lamp alone, therefore, can be considered a moderately effective source for increasing contrast.

Obtaining monochromatic light

In these studies a Bausch & Lomb high-intensity grating monochromator was used. This is a very effective device for obtaining monochromatic light, because wavelength is continuously variable over the entire visible region and the grating reflects a large percentage of the desired wavelength. Interference filters and colored glass filters (available from Bausch & Lomb, Baird-Atomic, Corning Glass Works, and other companies, and costing about $30) provide an alternative and considerably less expensive means if only a few wavelengths are needed.

Disadvantages of the mercury lamp

Unfortunately, high-speed photomicrography (exposure time <100 μ sec) is practical only with a xenon source in the form of a flash tube, since mercury and tungsten sources cannot be flashed. Mechanical shutter speeds are generally too slow for obtaining unblurred red blood cell photomicrographs in vivo (Wagner, Barker, and Filley, 1967). However, the intensity of any mercury line from a medium-wattage (<100 watts), high-pressure, short arc would be great enough for high-speed cinemicrography.

Figure 4 Photomicrographs of the same area of an everted hamster cheek pouch in vivo. Comparison is made of relative contrast at different wavelengths and color temperatures. Film type and development were identical for all exposures. About $\times$ 25.

Because of the high absorption of the high-energy photons that make up the violet line, a local heating effect of the intracellular hemoglobin can be expected. In addition, the photon energy approaches that where some photochemical damage might be possible. The ultraviolet photons produced by mercury lamps definitely possess sufficient energy to cause significant photochemical damage and should be filtered from the beam. However, the total energy absorbed by the erythrocytes from the mercury violet line is less than the total energy that would be absorbed by the cells when illuminated by white light from a xenon source of the same wattage. Because the visible radiation from such a xenon source is not considered harmful, it seems reasonably safe to assume that there is no significant thermal damage caused by exposing red cells to the mercury violet line at intensities sufficient for photomicrography.

Summary

The emission spectra and relative brightnesses of tungsten, xenon, and mercury microscope light sources have been compared to the absorption spectra of oxyhemoglobin for thicknesses ranging from that of the single erythrocyte to microvessels of 100 μ. It has been shown that contrast of unstained red blood cells to background illumination can be significantly enhanced in a controllable manner by transillumination of the cell with light of a wavelength selected to fall within one of the hemoglobin absorption bands.

Appendix

The absorption determinations were made by diluting whole human blood in a 0.1% Na_2CO_3 solution such that the HbO_2 concentrations were equal to vessels pefused by blood of 40% hematocrit and having internal diameters of 100, 25, and 15 μ (40% of 15 μ being equal to 6 μ or one red blood cell seen on edge). Six micron absorbances for the unfiltered light sources were measured by a photomultiplier tube with an S-11 surface corrected to the visual response curve by a photopic correction filter. Spectograms were run on a Gilford Model 240 Spectrophotometer and for practical reasons absorbances ≥ 2 were set equal to 2.

Acknowledgments

The authors wish to express their sincere gratitude to Messrs. Tom Innes and Edwin Licht for their valuable technical advice and to Messrs. Bill Wheeler and Larry Sampson for their criticism of the manuscript.

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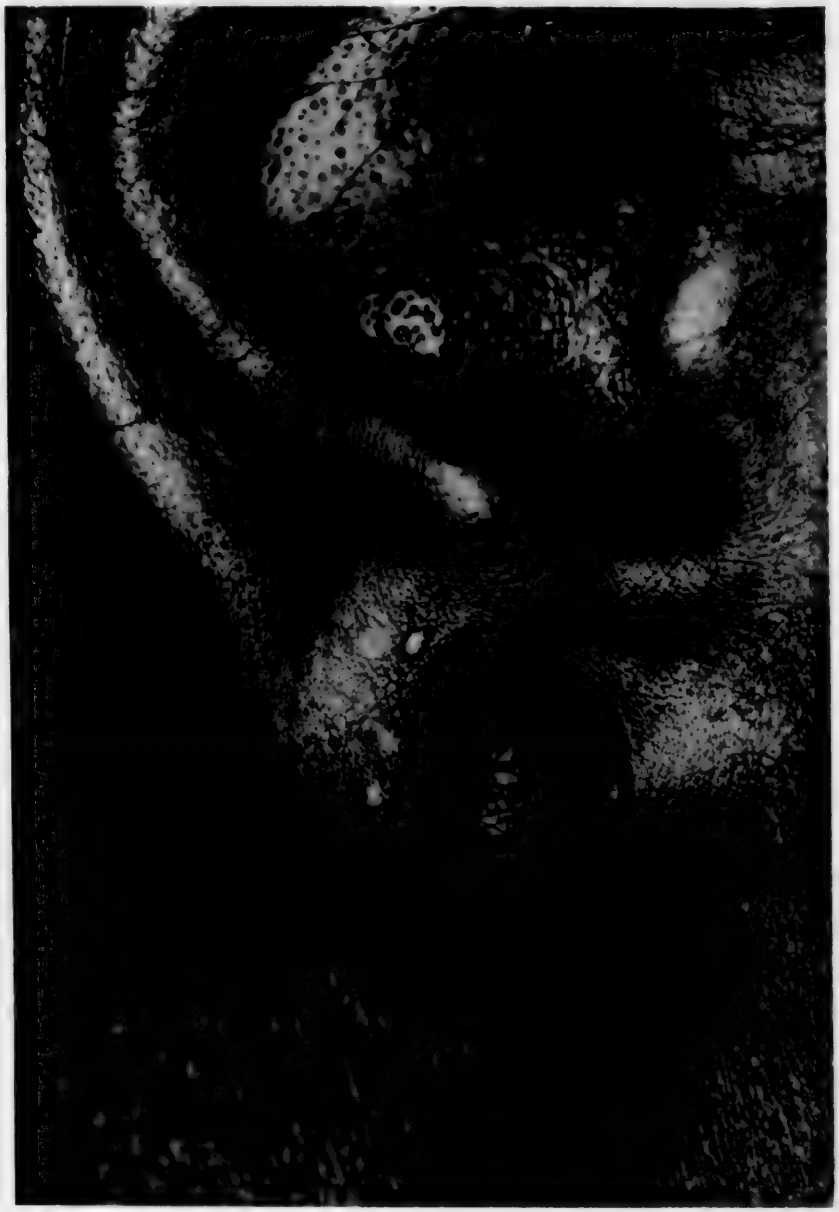
editor's choice

Both photographs here featured originated in the Princess Margaret Hospital in Toronto, and both received top awards in scientific photography. Mrs. Marianne Gaettens received First Award for Clinical Monochrome Print at the 38th Annual Meeting of the BPA for her entry entitled *Dermoid Cyst of the Eye*, and Miss Phyllis Grover received the SAMA-Eaton First Award for Professional Medical Photography for her entry called *Ears Pierced in 1967 — Year Later Keloids*.

Dermoid Cyst of the Eye — Marianne Gaettens



Ears Pierced in 1967 — Year Later Keloids Phyllis Grover

TECHNOTES

A THIRTEEN-MINUTE DIRECT-POSITIVE CONTINUOUS-TONE PROCESS

The solutions used in the process here described are prepared from liquid concentrate cine reversal mixtures made by the FR Corporation. For use, all these chemicals are diluted 4:1. They are FR Cine Reversal First Developer CR-1 (Catalogue No. 861), Bleach CR-2 (Catalogue No. 862), Clearing Bath CR-3 (Catalogue No. 863), Second Developer CR-4 (Catalogue No. 864). All these concentrates come in 5-quart containers. Conventional hypo is used for the fixing bath.

The film that has produced most consistent results is Kodak Panatomic-X, in FX 120 and FX 135 rolls. Information on these and other roll and sheet films that have been used with this process is given in Table 1.

Procedure

Maintain a temperature of 68° F for all solutions. Leave the film in the first developer for 4 min, continually agitating for the first full minute then for 15 sec of each remaining minute. Water rinse for 30 sec, the rate for this and each succeeding rinse being ½ gal per each 10 sec. Bleach for 1 min, agitating continually. After the film has been in the bleach for 30 sec, an OA safelight may be turned on. Rinse for 30 sec. Place the film in the clearing bath for 1 min, agitating continually. Rinse the film again for 30 sec. After the film is placed in this second water rinse, the room lights may be turned on for the remainder of the process. After the rinse, give the film a reversal exposure to strong light for 30 sec to each side of the reel.

Then place the film into the second developer for 1 min and agitate continually. Rinse the film for 30 sec, place it in the hypo for about 1 min, and wash it for 2 min. Place the film in a wetting agent such as photoflo and hang it to dry.

The total processing time is about 13 min. The amount of the first and second developer should vary with the amount needed to develop the film. The developer may be held for 7 to 10 days, after which it must be discarded. The bleach and clearing bath each have a much longer life.

This process works very well with copies of X rays and other continuous-tone material. For line copy, however, it gives a rather flat result.

The author would like to thank Mr. J. Robert Dant, Chief, Medical Illustration Service, Veterans Administration Hospital, Augusta, Ga., for his help in acquiring the film ratings shown in Table 1.

Table 1 ASA experimental ratings for, and results obtained with, various films used in the direct-positive continuous-tone process

Film	ASA experimental rating	Result
Kodak Roll Films		
Direct Positive	100	Excellent
Tri-X Pan, 120	200	Poor
Plus-X Pan Professional, 120	40	Poor
Plus-X Pan, 120	40	Poor
Panatomic-X, 135, 120	100	Excellent
Verichrome Pan, 120	250	Very good
Royal-X, 120	500	Very poor
High Contrast Copy	Not available	Very poor
Kodak Sheet Film		
LS Pan	2.5	Fair
Panatomic-X	2.5	Fair
Plus-X Pan	1.5	Good
Tri-X Pan	125	Good
Contrast Process Ortho	32	Very good
Kodalith Ortho, Type 3*	16	Very good
Gravure Copy**	80	Excellent
Fine Grain Positive	0.5	Excellent
Dupont Sheet Film		
Dupont Cronar Ortho Litho A	16	Excellent

*Can be used for both line and continuous-tone copy.
**ASA 125 with continuous-tone copy.

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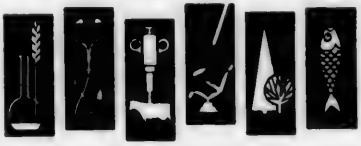
Received 30 August 1968

SHOPTALK



in the natural sciences

PHOTOGRAPHY OF INSECTS IN AMBER

In an earlier work (Blaker, 1965, p. 94) I included some specific but brief notes on photographing amber inclusions. Comment and reader interest has led to this expansion on the theme.

Many objects of biological interest can be found trapped and fossilized in amber, itself a biological material — fossilized resin (Langenheim, 1969). Such objects include pollen, seeds, and various kinds of vegetable debris, and the better known and visually interesting remains of insects and related small creatures. Some of this variety is shown in Figure 1. I will deal primarily with insects here.

Amber has been found in many areas of the world, but the best known source of insect-containing amber is the Baltic coast of northern Europe. Recently a deposit was located in Chiapas, Mexico (Petrunkovitch, 1964), and this is the source of all the material illustrated in the present article. Some 300 specimens of Chiapas amber inclusions are in the Museum of Paleontology, at the University of California, Berkeley. I am indebted to J. H. Peck, Senior Museum Scientist, and to P. D. Hurd and J. W. Durham, for information about and access to the collection. Museum identification information is included in all figure captions.

Amber is not a single homogeneous substance. It is found in a variety of types and colors according to the tree from which it came and the circumstances of formation. It has within it variations in visual density, and it contains bubbles, fracture planes, and general biological debris, all of which complicate photography. As found, it is typically an opaque, amorphous mass whose contents, if any, are not discernible. It must be cut into pieces of manageable size and transparency, inspected for fossil inclusions, and then recut, surface-polished and otherwise treated to make the inclusions available for close examination. Detailed instructions for this preparation have been published elsewhere (Langston, 1965, p. 287-293).

After even the best of specimen preparation, photography of good quality is not simple. In nearly all cases, the insects are very small, and they require photographic magnification of ×20 to ×40 to show them adequately. The surface of the cut block is seldom precisely parallel to the plane of orientation of the insect, although efforts are usually

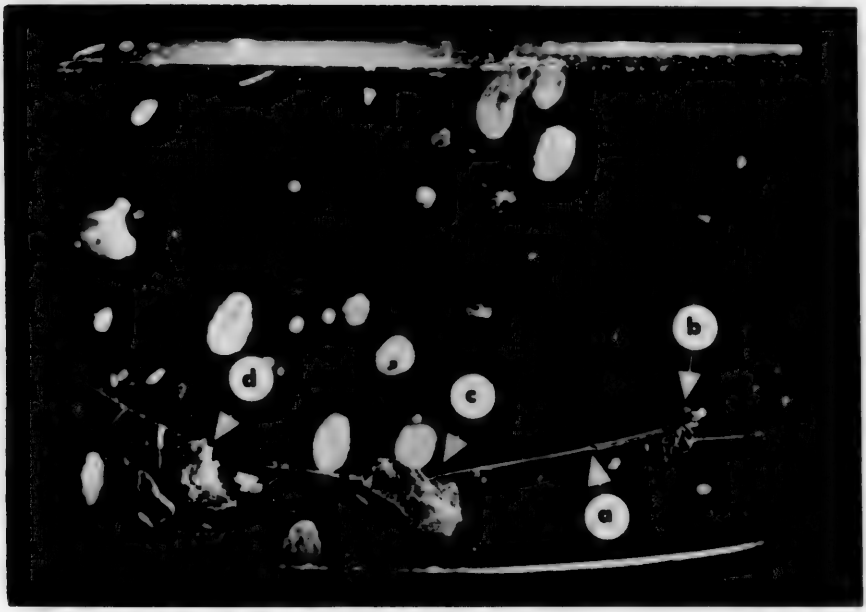


Figure 1 Block of amber containing (*a*) the remains of a spider web with, attached to it, three fossil insects: (*b*) Diptera: Phoridae, B-8413-196; (*c*) Blattaria nymph, B-8413-197; (*d*) Hymenoptera: Formicidae, B-8413-198. Vegetable material scattered through the block is not in association with the web, directly. Both *c* and *d* are web-shrouded; *b* is not. (All ×6. Higher magnification would yield much additional information.)

made to get them as nearly parallel as possible. External and internal reflections from the amber surfaces often interfere with photographic lighting. And after all else is worked out, interference is presented by bubbles and other extraneous inclusions.

In addition to the need for great care in lighting, the two greatest problems are the exact alignment of the main axes of the insect with the focal plane, and the suppression of undesirable effects produced by nonparallelism between insect and amber surface. Figure 2 illustrates a good method for controlling both problems. Alignment is achieved through the use of a simple three-dimensionally adjustable holding clamp, this particular one being the design and construction of Mr. V. G. Duran, who also taught me the use of it. After being placed in the clamp, the specimen is observed through a dissecting microscope. With one eye closed to eliminate stereo vision, adjustments are made until the subject is correctly positioned.

If the upper surface of the amber block is then not parallel to the insect, there will usually be a lack of sharpness and/or a linear distortion of the image, both of which are due to the different depths of amber being penetrated by the line of sight. Liquid immersion of the whole apparatus is, then, the next step. The amount of liquid should be just sufficient to cover the specimen block, so that the needed close approach of the lens can be made, but with the provision that the lens

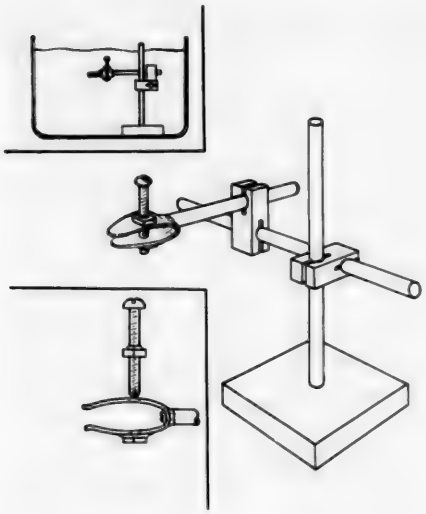


Figure 2 *Right*, three-dimensionally adjustable specimen clamp made of brass (by V. G. Duran). *Upper left*, assembly immersed in a dish of oil. *Lower left*, constructional detail of the clamp itself, which is sprung to remain open and is adjusted and closed by the screw.

does not enter the liquid. Even water is a better immersion medium than air, but oils are usually much the best. So far as I know, there has been no determination of the index of refraction of Chiapas amber, possibly because of block to block variations. However, ordinary mineral oil makes a generally satisfactory immersion medium. Figure 3 *A* shows a subject photographed in air and displaying evidence of both surface reflections and image distortions as described above. Figure 3 *B* shows the same subject photographed while immersed in mineral oil. The importance of oil immersion varies with the circumstances. Figure 3 *C* is of a subject which I photographed equally well in air and in oil. However, most specimens require the oil.

As for lighting, the best system is usually a single source, direct or diffused according to individual need, and with due attention paid to lighting angle. This kind of lighting is most often used in conjunction with a white or light background placed close to and under the subject, and therefore also immersed in the oil. Since paper or card becomes translucent in oil, the best material is a small piece of white plastic.

Great care must be used in choosing a lighting angle that shows up all the species-diagnostic features of the subject while avoiding lighting artifacts. Figure 3 *D* is an example of a case where directional dark-field lighting from below was used to show the wing veining, while a balanced degree of top lighting was

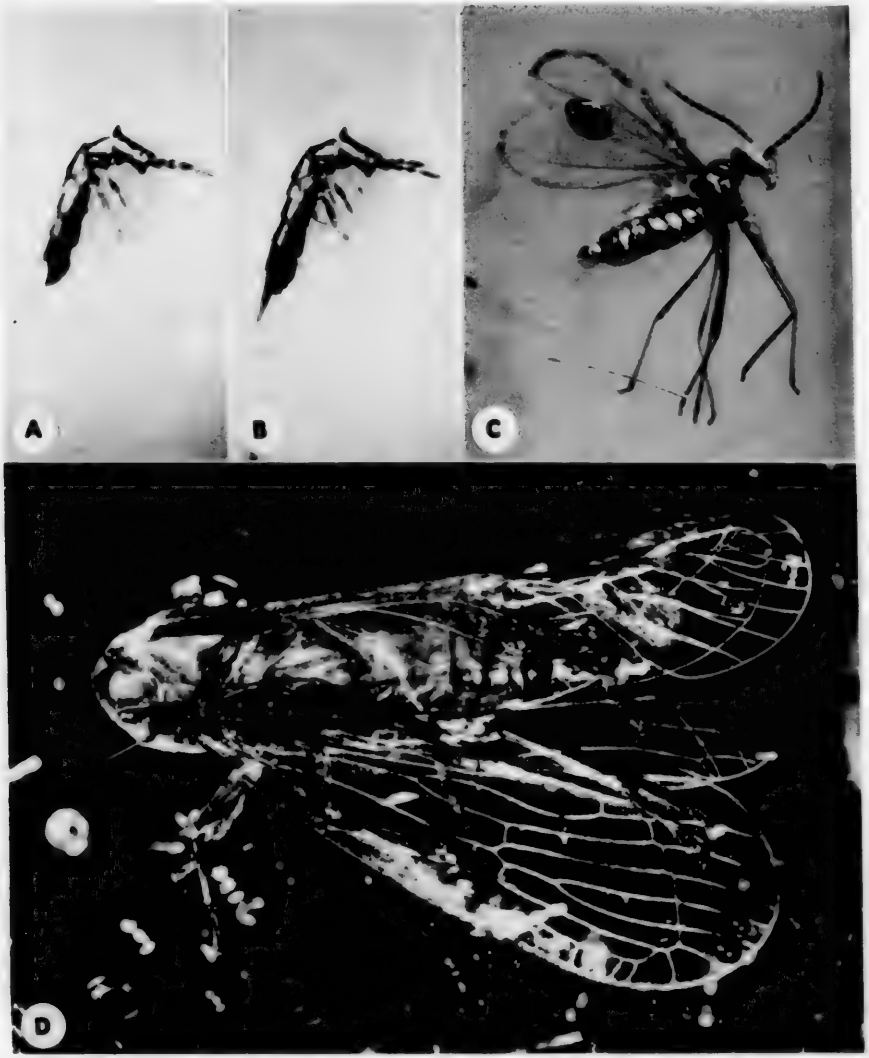


Figure 3 *A*, Subject (*Isotomurus retardus* Folsom, B-7041 (13501)) photographed in air. (Courtesy of P. D. Hurd) (×40). *B*, Subject same as *A*, photographed immersed in mineral oil. *C*, Subject (Diptera: Cecidomyiidae, B-8421-14) photographable equally well in air or oil (×25). *D*, Subject (Homoptera: Fulgoridae, B-8421-9) requiring complex lighting (×20).

used to show surface characteristics. Figure 1 also required this combination of lighting to show both the web and the insects caught in it. Figure 3 C shows a subject with an air bubble caught between its wings. I have found no way of countering the highly visible effects of bubbles at or near the subject plane.

For other photographic aspects, normal photomacrographic equipment and techniques are used. Black-and-white films are most appropriate, because the overall color of the amber results in a monochromatic image anyway.

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letters to the editor

Phase contrast

In the first issue, 1969, of the Journal of BPA, Dr. Charles L. Schneider states on page 37, when writing on phase contrast: "The enhanced differentiation of phase-contrast imagery permits resolution beyond the limits otherwise defined for the conventional light microscope."

I don't think this statement is valid. Phase contrast enhances contrast and not resolution.

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NEW PRODUCTS

Information is that of manufacturers. No endorsement by the author, his employer, or the Biological Photographic Association is intended.

HIGHLIGHTS OF WEST GERMAN INDUSTRY AT 1968 PHOTOKINA

Progress in electronic shutters, lenses and optical glass, and development of cameras tailored to specific consumer demands characterized the West Germany camera industry's offering at the 1968 "Photokina" World's Fair of Photography at the Cologne Fair Grounds.

In the two years since Photokina 1966, few sensations were produced, and pre-Photokina disclosures had revealed many of the product developments of West Germany's leading manufacturers. Yet the industry's "state of the art" exposition incorporated a number of fascinating new-product highlights that commanded the attention and interest of the consumer trade and the consumer public.

A notable breakthrough was achieved by Agfa-Gevaert in the development and production of a film with a 1000 ASA speed rating, Agfapan 1000 Professional, which is being produced in sheets, rolls, and 35 mm.

Other significant innovations from the camera industries of the West Germany company group were:

- Compur's electronic shutter No. 1 (added to the No. 3 and No. 5FS series); and a new family of Compur electronic-m long-life shutters, which are magnetically actuated as well as electronically timed
- Isco's new quality lenses for copying and microfilm applications; and some of the world's most competitively priced and enlarging lenses
- Prontor's new plate-type electronic shutter with built-in CdS cell, which will add a new continuous range of shutter speeds to inexpensive ultra-compact cameras; and new developments in the firm's 500, 300, and 250 electronic shutter range
- Rodenstock's expanding series of camera, enlarging, and technological lenses, 21 new models in all, including two lenses in a new "Gerogon" series for electrostatic copying equipment
- Rollei's pioneer development in Braunschweig of two new studio flash generators of enormous watt-second output and extreme efficiency; a first in pocket-size self-quenching electronic flash; a powerful cigarette-pack-dimensioned hot-shoe unit; the Rolleiflex SL 26 camera; and a kit of Rollei SL 66 accessories that include lenses with integral synchro-compur flash shutters
- Schneider's new "Scheimpflug" Xenar lens with depth-of-field control
- Schott's three new optical glass developments, which open unexplored vistas to photographic lens designers

- Zeiss-Oberkochen's new Vario-M-Sonnar lens for the Hasselblad system with its integral ring-lamp, a new unified concept for close-up photography embodying the first zoom lens for a $2\frac{1}{4} \times 2\frac{1}{4}$ camera. (It's so simple that neither lens aperture nor focal length are specified.)
- Zeiss Ikon-Voigtlander's achievement of the Contarex SE superelectronic SLR system; the Zeiss Hologon ultra-wide "35" camera; the Vitessa 1000 SR camera with its 1/1000 sec between-the-lens Prontor shutter; and the Moviflex MS 8 Synchron camera, which extends the possibilities of impulse-generated lip synchronization in Super-8 filming to a wide assortment of commercially available tape-recording systems
- Agfa-Gevaert's new hardware: the Movezoom S2 Super-8 camera with electronically actuated 3-sec fading, and power zoom; Sonector 8 automatic sound projector for magnetically striped Super-8 film (up to 400 feet); and two pocket-size Agfatronic flash units with man-size output.

Additional information on the subjects mentioned may be obtained from the manufacturers or their representatives.

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Received 27 February 1969

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Ability in photographic research in new methods or materials.

The foregoing require submission of evidence.
Meritorious contributions to biological photography overall through sustained organizational work.

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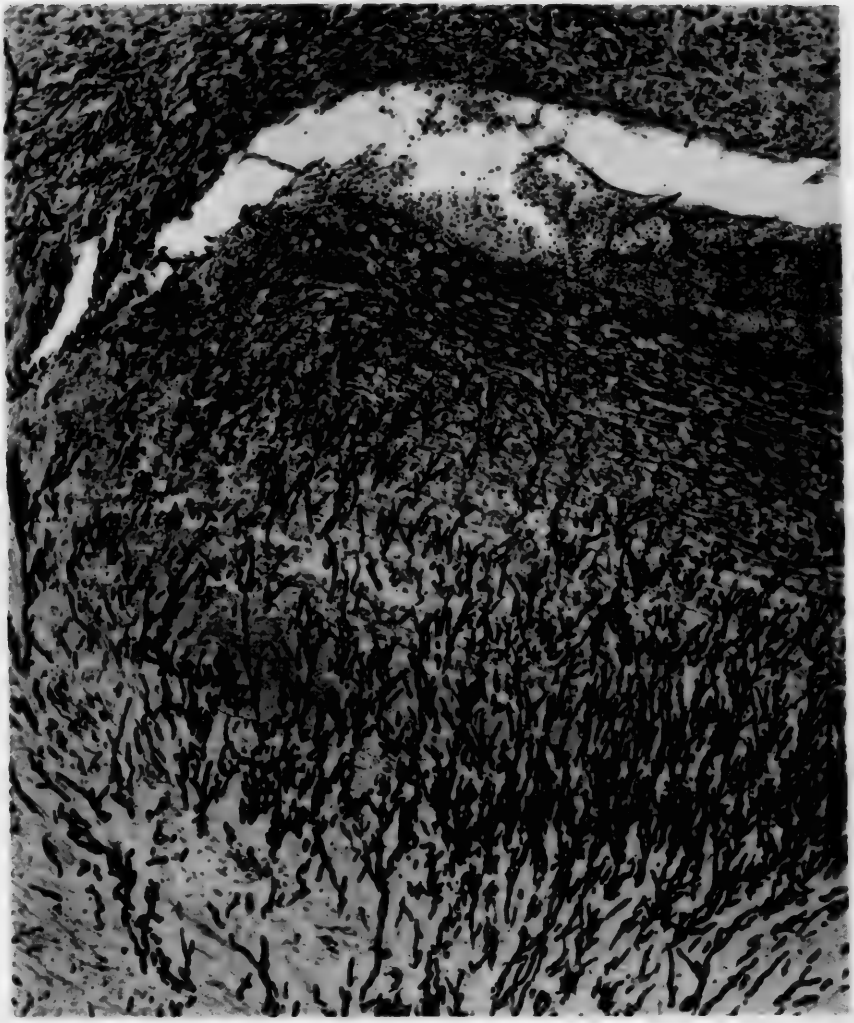

J. BIOL. PHOTOGR. ASS., VOL. 37, NO. 4, P. 177-232, OCTOBER 1969

Cover Photograph

Fungus organisms in lung tissue, taken by Gebhard Gsell, National Institute of Health, Bethesda, Md.

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The Association is an international professional organization of scientific photographers and other communications specialists who work in the natural and health sciences. Persons interested in scientific photography, but whose vocational status does not qualify them for active membership, may join the Association as affiliate members.

The B.P.A. was founded at Yale University, in 1931, by a group of scientific photographers, to provide a forum for the dissemination of information on methods, techniques, materials, and instrumentation as applied to scientific research and teaching. The B.P.A. has now over 20 chapters in the United States, Canada and India, with over 1000 members. There are also numerous members-at-large in many countries throughout the world.

Three classifications of membership are available: active, affiliate and sustaining. In recognition of professional excellence, award plaques and certificates are conferred annually for the best scientific paper published in this journal and presented at the annual meeting, and for outstanding contributions to still and motion pictures and TV tape exhibits. Fellowship in the B.P.A. is conferred for significant achievements and meritorious contributions to the advancement of photography in the biological sciences.

Annual meetings are held every autumn for the purpose of presentation of scientific programs of papers, workshops, scientific and commercial exhibits, and refresher courses. Regional and chapter meetings are also held.

The B.P.A. publishes this journal and the Newsletter, which informs members about chapter activities, personal information, and employment opportunities for scientific photographers.

The B.P.A. has established and maintains a Board of Registry for the purpose of examining and certifying qualified scientific photographers. The aim of this certification program is to raise standards and provide criteria for those interested in employing qualified scientific photographers. This program has been established in consultation with the United States and Canadian medical associations, hospital associations, dental associations, the American Institute of Biological Sciences, and several other influential professional societies.

Further information about the B.P.A. may be obtained from Mr. R. M. Christopher, Executive Secretary, P.O. Box 12866, Philadelphia, Pa., U.S.A. 18108.

Inquiries regarding the Certification Program are to be addressed to the Secretary of the Board of Registry, Mr. Will E. Renner, Medical Illustration Service, School of Medicine, University of California, Davis, Calif., U.S.A. 95616.

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meetings calendar

40th Annual Meeting
Biological Photographic Association, Inc.
held jointly with the
Association of Medical Illustrators
August 10 - 13, 1970
Houston, Texas

See Prospectus, page 22

LYNN BALDWIN, RBP, FBPA
General Chairman, 40th Annual Meeting
Department of Medical Communications
M.D. Anderson Hospital
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41st Annual Meeting
Biological Photographic Association, Inc.
International Congress on Scientific Communications
August 23 - 27, 1971
Chateau Laurier Hotel
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in black and white

The beginning of a new academic year affords an excellent opportunity to give some thought to our educational problems. For many years biological photography blossomed on the peripheries of other fields of scientific endeavor. The photographer provided services to the best of his ability. Though his offices may often have been mediocre at first, he developed his knowledge and skills through many years of practical experience and occasional participation in some short courses or scientific meetings. Recent technology gave a tremendous rise to biological photography, opened new possibilities for those with a creative mind, and posed a new challenge for all of us.

The complexity and variety of instrumentation, methods, and materials used by biological photographers require sound knowledge of underlying principles of photographic chemistry and physics, as well as practical knowledge in a number of related fields such as electronics and sonics. This knowledge can no longer be acquired without organized professional education at a technological institute or university. Furthermore, scientific photography is now only one of several communication methods used in research and teaching; art, photooptical instrumentation, cinematography, and television are some of the others. Unless the biological photographer becomes a multimedia specialist, he will be dominated by artists, photooptical engineers, or television producers, all of whom have the advantage of university education. Just as the dean of a faculty is in most cases distinguished in only one field of scientific endeavor, and cannot possibly be a specialist in every discipline taught at his institution, the head of a scientific communications establishment is usually highly qualified in one field and has only general knowledge of other fields. However, since the academic world is used to judge parascientific professions by its own standards, scientific photographers will not enjoy full professional recognition until an academic degree is required for entrance to the profession.

Unfortunately, the transition of biological photography from a trade to an academic profession is slow in arriving. Too few of those who are already professionally engaged in biological photography are sufficiently interested in advancing their knowledge through intensive

studies at extension divisions of universities and technological institutes. Most towns and cities now have degree-granting institutions that offer evening courses leading to bachelor and master degrees. A few institutions even offer undergraduate and postgraduate courses in subjects directly related to scientific communication. Unless the biological photographer uses every opportunity to further his educational standing, other university graduates, often from completely unrelated fields, will quickly establish themselves as communication experts and leaders in this new and highly promising profession. Evidence of the need for higher education makes itself felt more strongly now than ever before. Every product, process, and job must be related to the whole picture. Every thought for the development of the services we provide has its origin in the mind of someone. Cultivation of the mind, therefore, is essential. Without formal professional education the biological photographer will sooner or later find himself in a dead-end job.

The department of biomedical photography recently established by the Rochester (New York) Institute of Technology is a foremost alma mater for all biological photographers. Hopefully, more technological institutes and universities will follow suit and establish degree courses in scientific communications; but even more important is for biological photographers, regardless of the length of their practical experience, to take full advantage of every available opportunity to obtain university education.

Stanley Klosevych

EXHIBITION PICTURES — AN INVITATION

The editors invite those who exhibited in the Scientific Salon, 39th Annual Meeting, held in Rochester, Minn., last August, to submit 8×10 copies of their exhibits to this journal for possible publication on the cover or in the *editor's choice* department.

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Muscle graph of tetanus contraction

ROBERT A. RINALDI

Motion displayed by a biological system can graph itself on photographic film by time exposure of the moving system. First it is necessary to enhance, by either special dark-field illumination of naturally occurring granules (Rinaldi and Jahn, 1962) or by spots tattooed with India ink (Haupt and Wall, 1962) the moving "image's" ability to record itself. The resultant graphs are composed of streaks, which represent the speed of the system during its motion. The fastest moving spots record as long streaks, slower spots as short streaks, and spots that do not move at all appear as dots. With this technique it is possible to obtain a record of the kinetics exhibited by the system over a selected time interval. It is inexpensive and easily accomplished.

Because of the rapidity and other difficulties encountered in photographing a "simple" muscle twitch, a tetanus muscle contraction was selected to illustrate the possibilities of this technique's application to studies of whole muscle contraction. A tetanus muscle contraction results when a number of stimuli are applied in rapid succession to the muscle with insufficient time for relaxation. Therefore, the muscle in this experiment goes from a relaxed state to maximum contraction in the selected time interval.

The gastrocnemius muscle of the frog was isolated with the sciatic nerve. This muscle was attached to its femur bone held anteriorly by a standard femur clamp and tied posteriously by its Achilles' tendon to a typical muscle lever system used in kymographic recordings. Immediately after its isolation, this muscle was placed in ice-cold (5°C) Ringer's solution. During the experiment, cold Ringer's solution was dropped on the muscle to prevent any possible heat damage from the intense photoflood lamps. The muscle was tattooed by carefully and rapidly injecting minute quantities of India ink beneath the perimysium with a No. 27 hypodermic needle.

Stimulation was obtained with an inductorium, battery, and leads to the sciatic nerve. A 35-mm camera was attached to a horizontally arranged dissection microscope. Opening of the shutter not only controlled exposure time but also functioned as a switch that engaged the electrical circuit, which stimulated the muscle. The duration of stimulation and of the shutter's opening was 1 sec.

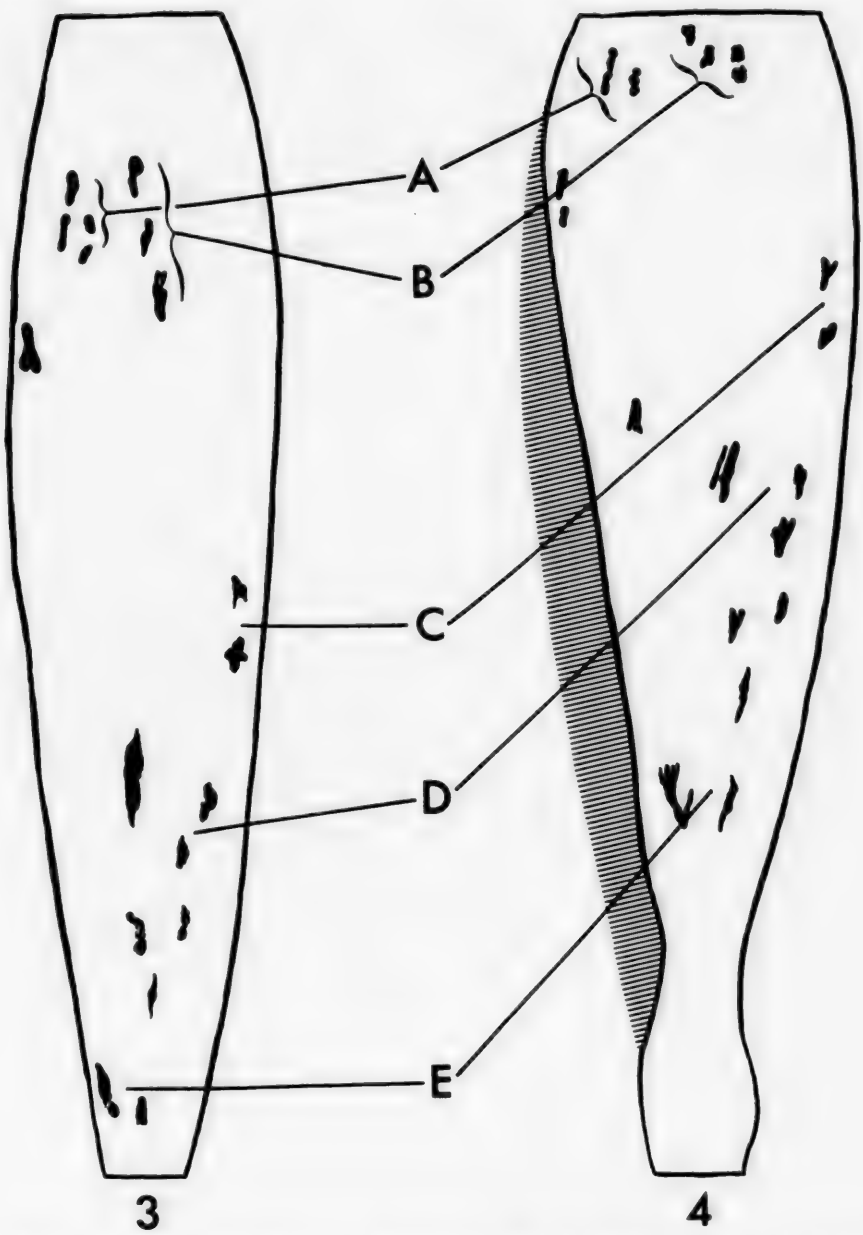
ABOUT THE AUTHOR

Study for this paper was done when Robert A. Rinaldi, PhD, was with the Department of Anatomy, School of Medicine, Vanderbilt University, Nashville, Tenn. 37203. Dr. Rinaldi is at present in the Department of Anatomy, Georgetown University Schools of Medicine and Dentistry, 3900 Reservoir Road, N.W., Washington, D.C. 20007.

Figure 1 A one-second photograph of an unstimulated muscle.

Figure 2 The same muscle undergoing a tetanus contraction for one second.

Figure 1 shows the unstimulated muscle photographed for this 1 sec; the area photographed includes a ruler. Note the black spots underneath the perimysium. Indistinct spots are caused by "running" of the India ink along the fibrils. To study this contracting system, certain spots were selected and labeled in the outlines (Figures 3 and 4). Since it is difficult to represent the ink spots accurately, the reader should also look at the actual photographs (Figures 1 and 2).



Figures 3 and 4. India-ink tracings emphasizing some of the details recorded in Figures 1 and 2.

In Figure 2 the stimulated muscle is undergoing a tetanus contraction. Note the streaks, which result as the tattoo marks graph themselves during their contraction. The muscle is oriented to approximate the same position as in the frog's leg. Motion of the spots tends to be blurred, but the data may be easily extrapolated from the outlines and actual photographs, which depict accurately the events of this tetanus contraction.

In Figure 2, note also the original position of the muscle at the left indicated by the faint outline of the muscle and further emphasized by the shaded line in Figure 3 *B*. The area between the faint and the more prominently recording outlines of the contracting muscle reveals three "ghost outlines," which indicate that the contraction is not uniform. This lack of uniform contraction probably reflects the increasing number of muscle cells being brought into a state of contraction during stimulation.

Examination of the streaks in Figure 2 is of particular importance. True, the streaks are blurred and faint, but it must be borne in mind that these spots are in motion. The streaks are important because they indicate direction and the original position of the muscle. But the final phase of the tetanus contraction is recorded here for the longest period of time, and this fact is revealed by the darkness of the spots near the "end" of the contraction (Figure 2).

Quantitatively, there exist several facts that are important in this depiction of a tetanus contraction. Comparison of diameter in the photographs of the muscle at region A (Figures 3 and 4) shows that the top of the muscles has increased in girth approximately 2 mm, whereas near the bottom (at *E*) the diameter of the muscle is seen to have increased approximtely 1 mm. Examination of the displacement of the spots reveals two components of motion. The muscle is moving both upward and toward the ruler. Note, for example, the spots near the label *B*. They have moved approximately 5 mm toward the top of the muscle and about ½ mm toward the ruler. Observe the striking change in relative position of these granules (*B*) to one another; this change in position demonstrates that these spots on the muscle are not moving uniformly relative to one another. But this is to be expected, because a great deal of change in shape occurs in the contracting muscle.

In the central portion of this muscle (labeled C), it can be observed that the spots have moved about 8 mm toward the top of the photograph and 1 mm toward the ruler, which, incidentally, is not exactly parallel to the muscle. In the lower portion of the muscle (for example, at *E*), the motion exhibited is 8 mm upward and slightly toward the left side of the photograph. Other spots can be selected and their motion during contraction can be observed.

From the streaks it might be surmised that the muscle has rotated, and this may be true in the sense that the muscle is bulging here. However, though the muscle exhibits a torsion during its contraction, the fact is emphasized that the Achilles' tendon (Figure 2, *bottom*) is in the same relative position as the original position of the terminal part of the muscle (Figure 1, *bottom*). Thus, lifting is directly upwards, and such lifting would tend to ensure a certain efficiency during this muscle's contraction.

A possible error has been introduced in the photographs by the slight shift in position of the spots towards the photographic film. However, this error is small,

and only if exceptional accuracy is required must it be corrected.

Certainly, it is instructive to have a picturization of the process of muscle contraction. Previously, studies on muscle contraction have been more concerned with the movement of a lever and its "writing" on a sensitive rotating drum. There are exceptions, of course, which have taken a more direct approach by using photographic techniques. For example, Heilbrunn (1952) demonstrated a complete contraction exhibited by a muscle fiber in a series of ten photographs. Recently, Haupt and Wall (1962) reported the use of a high-speed cine apparatus to record the events of a single muscle twitch. Disadvantages of the cine method are the expense and the fact that the kinetic recordings must be reconstructed from several frames of the cinefilm. The technique and results I have reported here give a complete characterization of a tetanus muscle contraction in two photographs (maximum). The technique requires no elaborate equipment, and most scientific laboratories are sufficiently well equipped to achieve photographs of motion. Moreover, and more important, the data are a record of the biological system's own motion, and this muscle has graphed for the reader its own motion during tetanus contraction.

Acknowledgment

Work for this paper was supported in part by Tennessee Heart Association, Inc.

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Received 12 November 1968

An automatic recording unit for photographic studies of behavior of domestic animals

VICTOR R. SQUIRES, GORDON T. DAWS, and RONALD A. BAWDEN

Abstract

An automatic unit incorporating both mechanical and photographic recorders is described. It is portable, inexpensive, rugged, dependable, and independent of electric power mains. Field performance in studies on social behavior, organization, and leadership in small flocks of sheep is described. Temporal patterns of activity were determined by this automatic recording technique. Its application to studies of behavior in other animals, both domestic and feral, is discussed.

Introduction

Traditionally, visual techniques have been in the basis of research on behavior of domestic animals both in the field and in the laboratory (Hafez and Scott, 1962). Still photography and more recently cinematography have supplemented these observations (Arnold, 1968). Cinematography has been used to record behavior patterns in sheep (Scott, 1945; Banks, 1964), and studies on pigs (Facto and Catron, 1961), on sheep (Arnold and Bush, 1968) and on cattle (Rutter, 1968) have illustrated the value of time-lapse cinematography for analysis of behavior patterns.

In our studies on behavior patterns in sheep, we sought a means other than visual observation to provide precise information on social behavior, organization, and leadership in small flocks. Accurate determinations of walking speed and of temporal patterns of behavior were also required. This information called for an apparatus that would:

- maintain its operation unattended for seven days
- allow free and unimpeded movement of subjects
- be inexpensive, rugged and dependable
- provide permanent records for subsequent analysis
- give a contemporaneous account of movement patterns
- be independent of main power supplies
- be portable.

ABOUT THE AUTHORS

Mr Victor R. Squires, a graduate of the University of New England, in Australia, is engaged in research on the grazing behavior of sheep in relation to vegetation and environment. Mr Gordon T. Daws and Mr Ronald A. Bawden are Technical Assistants. The authors are in the Commonwealth Scientific and Industrial Research Organization, Division of Plant Industry, Riverina Laboratory, Deniliquin, New South Wales, Australia.

Figure 1 View of experimental laneway for studies on social behavior, organization, and leadership in sheep.

This paper describes a new application of automated photography that does not involve time-lapse devices but rather depends on the animals themselves to actuate the camera at precisely determined points and times, under the specific motivation of the need for sustenance.

Experimental site

Our chief aim was to test the walking ability of sheep in a field environment, because this ability is a critical factor in their survival in semiarid pastoral regions. To restrict lateral movement and to simplify recording, the walking area was made into long narrow laneways, each with a water supply at one end (Figure 1). Feed was supplied at a predetermined point up to a maximum of 4 miles from water. The passage of

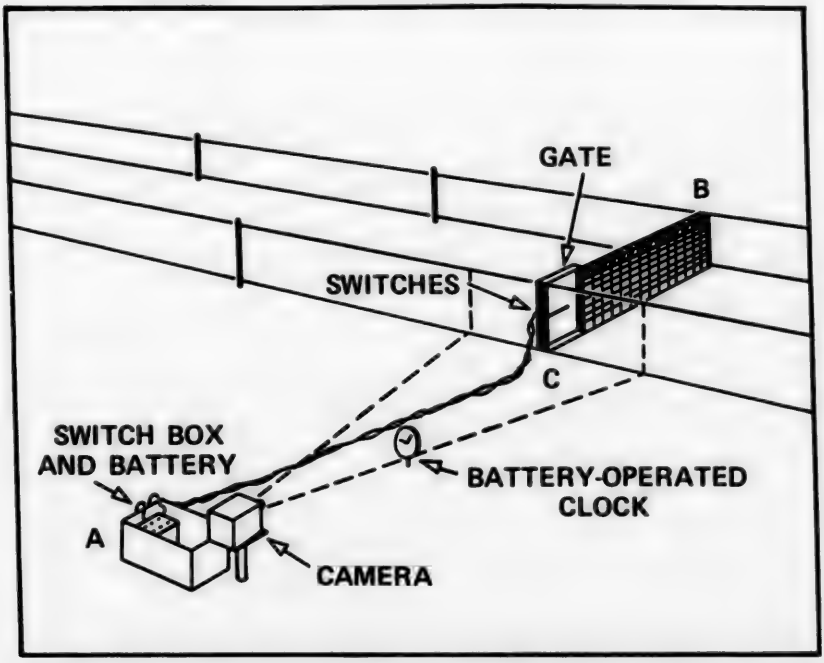


Figure 2 Unit in laneway, showing relative placement of components.

individually marked sheep was recorded automatically by units set up near the water and feeder and at intermediate sites about 1 mile apart.

Subjects

Twenty Merino wether sheep were run as a single flock during a training period of 30 days. For this training the animals were placed in a laneway, without food other than that provided in a self-feeder 1.5 miles from water, the only access to this feeder being through several narrow gateways en route. Each animal was branded on both sides, at the shoulder and the flank, with numbers 6 inches high.

Recording unit

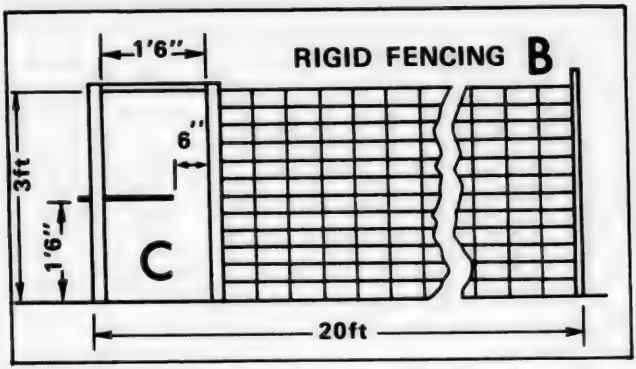
Description

The laneway in which leadership, temporal patterns of behavior, and average walking speeds were determined was partially blocked at points, leaving only a narrow gateway (Figure 2, C). A device for triggering the recorder (Figure 3) was mounted on the gateway and comprised two microswitches and a flexible hinged rod, one end of which was flattened to ensure positive depression of the microswitches. When an animal passed through the gateway the rod was moved in the same general direction as the animal. The horizontal component of this directional rod movement is sufficient to move the flattened end the ¼ inch needed to depress the microswitches. The length of the rod and its height above ground was determined experimentally, as was the overall height of the channel-iron framework. The dimensions chosen (Figure 3) ensured that medium to large sheep could not avoid contact with the rod.

The unit is shown in a series of diagrams, Figures 3 and 4. For the device to function, one of the two sheep-actuated microswitches (Figure 3) must be closed to complete a 2-v d-c circuit containing a 0.2-amp electric motor (Figure 4). The motor is connected to a gearing system (Figure 4) capable of a final drive output of 2 rps. A nylon cam of maximum radius 0.4 inch fitted to the output drive (Figure 4) was mounted so as to actuate two microswitches simultaneously. One of these switches is wired in series with a 6-v battery, and a standard automobile solenoid switch is connected to a pivoted tip bar (Figure 5). When this 6-v circuit is closed by the cam-actuated switch, the solenoid lifts the tip bar and in so doing depresses a camera cable release plunger. Once the circuit is opened by the cam moving up from this switch, the tip bar falls, pulling with it the cable release plunger and single frame of cinefilm is exposed. A simultaneous record is transferred to a chart by a Kienzle 8-day Vibracorder attached to the tip bar (Figure 5). The Vibracorder is an instrument that transmits movements by means of a freely oscillating pendulum attached to a stylus and records oscillations on a waxed circular paper chart, which is synchronized with a clock mechanism for continuous recording. The Vibracorder is manufactured by Kienzle Apparate GmbH, Villingen/Schwarzwald, West Germany.

The second cam-actuated switch is wired in parallel to the switches at C in Figures 2 and 3 and in series with the motor and 2-v battery. This method of wiring prevents any possibility of the solenoid circuit remaining closed for longer than about 1/10 sec.

A battery-operated calendar clock was placed in the middle foreground and a



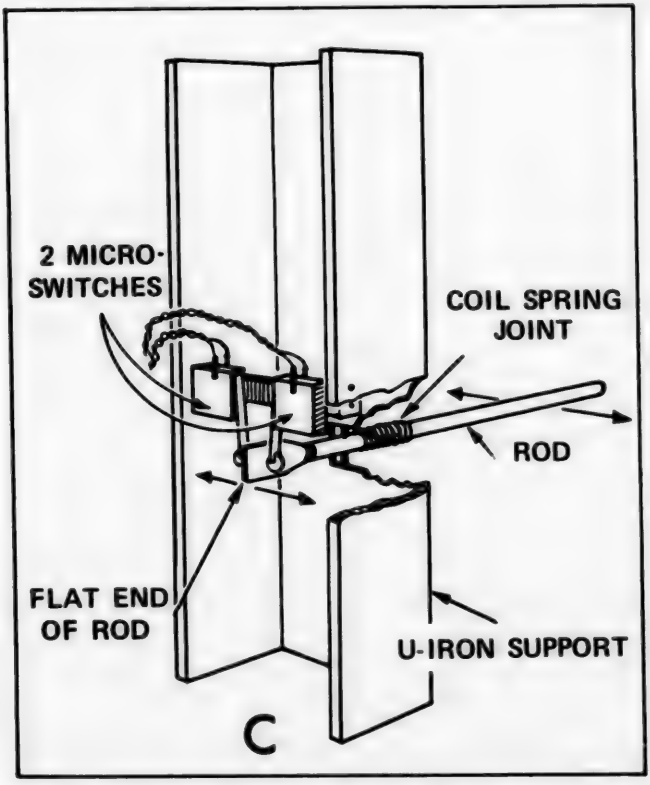


Figure 3 *Above*, (C), triggering rod and switching and, (B), fencing at gateway. *Below*, (C), detail of triggering rod and switching.

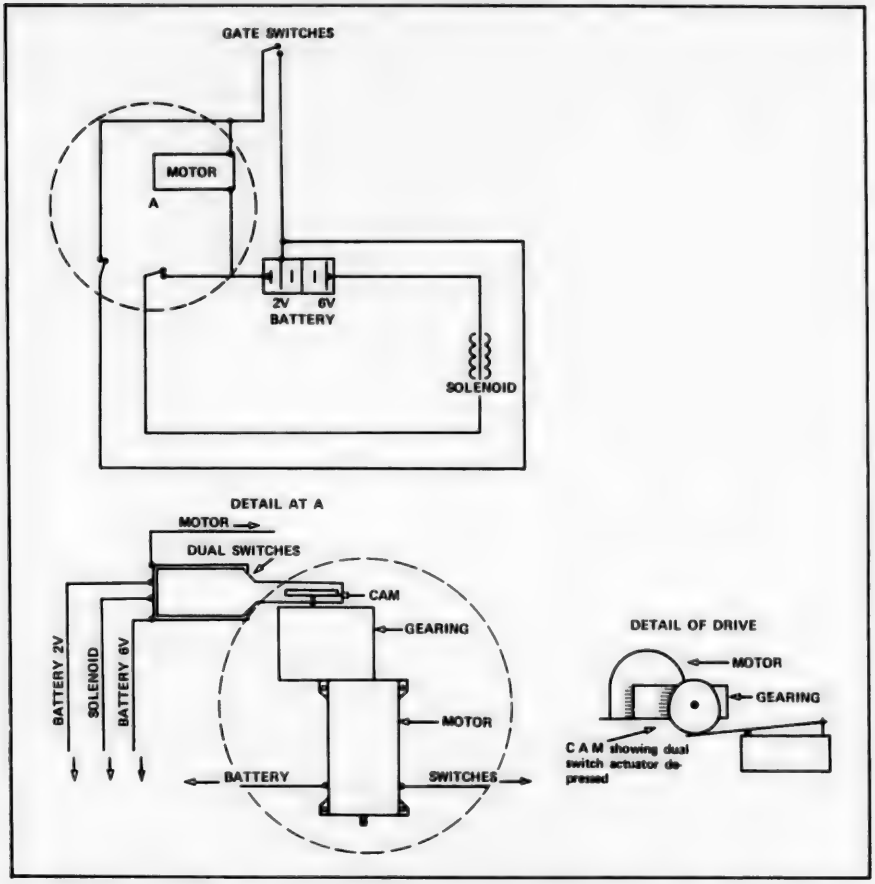


Figure 4 Circuit diagram and detail of switching components.

site-identification plate attached to the fence, both within the camera field of view. Thus each photograph shows time, date, and site, as well as the identity of each sheep (Figure 6).

It was not possible to distinguish between the records made by individual sheep on the Vibracorder charts because of the slow chart speed (< 0.6 inch per hour). Despite this disadvantage, the Vibracorder records proved especially valuable because they were not only synchronous with the camera operations but also independent of camera failure, had both day and night and all-weather capability, and could be examined in situ at any time while the instrument remained in operation.

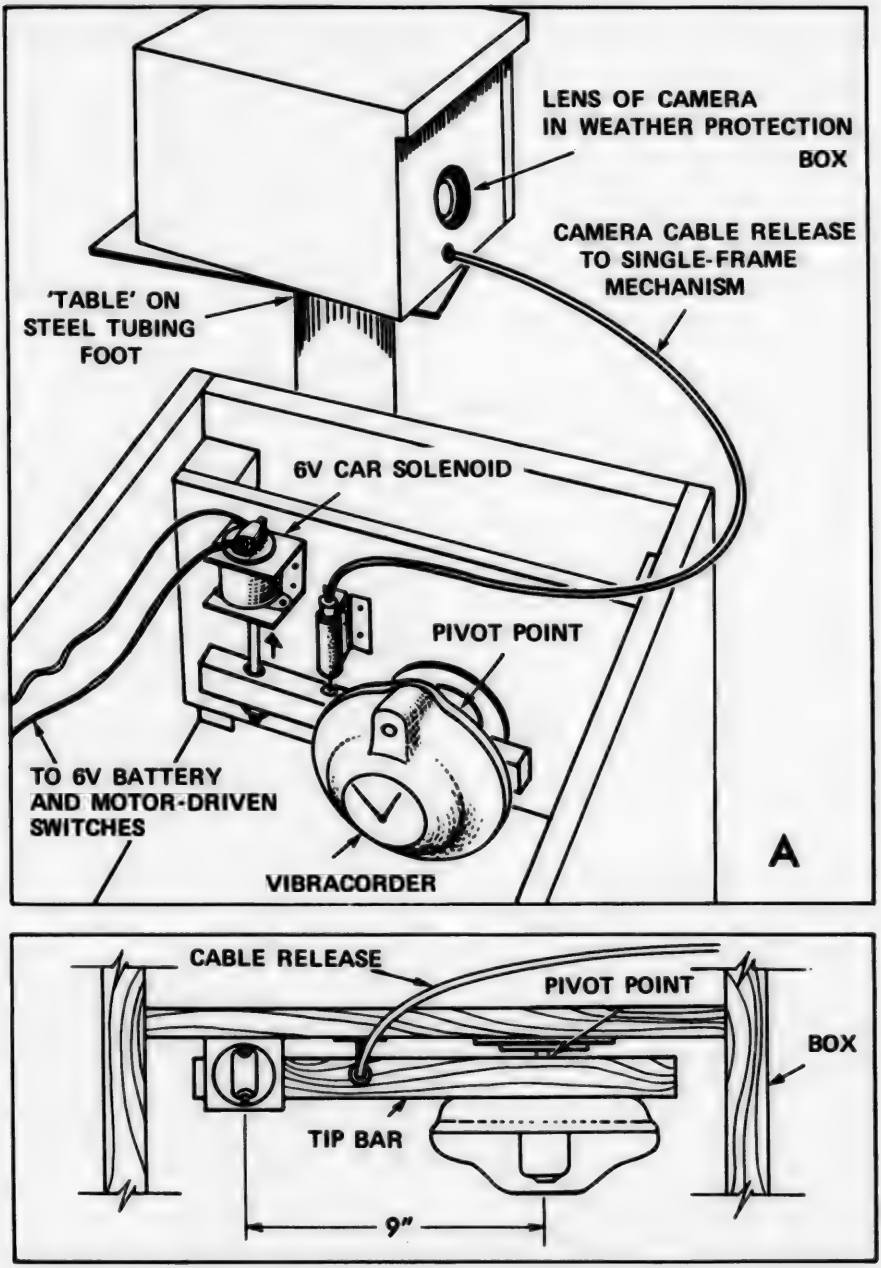


Figure 5 Detail of recorder and camera installation.

The cameras used were Kodak Instamatic M6 cinecameras, which accept Super 8 cartridges for instant loading and unloading and feature single-frame capability, through-the-lens exposure control and built-in color-conversion filter. To give a field of view of 6 feet at the fence the 12 to 36 zoom lens was set at about 25 mm. Kodachrome II Type A film was used.

Field Performance

Observation confirmed that the recorder units accurately recorded the passage of each sheep through the gateway even when the animals ran through the gateways at up to 8 mph. Movement of the animals was free and unimpeded (Figure 6).

Six of the units were used continuously for 7 months under dusty conditions when recorded temperature reached daily maxima of 80 to 115° F. Protection of the cameras was minimal (Figure 5) yet no damage occurred. No additional precautions were taken to make them dustproof. Even under these rigorous conditions the units proved to be very reliable.

The rate of film exposure was such that a film cartridge of 50 feet lasted approximately 8 to 10 days when sheep were passing through twice daily, and a proportionately shorter time when the frequency was increased. This rate of exposure permitted an adequate margin of safety as chart-changing was on a weekly basis.

The low ASA rating of Kodachrome II film (ASA 25 when color-corrected) was not a disadvantage since most activity occurred during daylight hours. Good photographs have been obtained under all weather conditions and acceptable imagery has been recorded both after

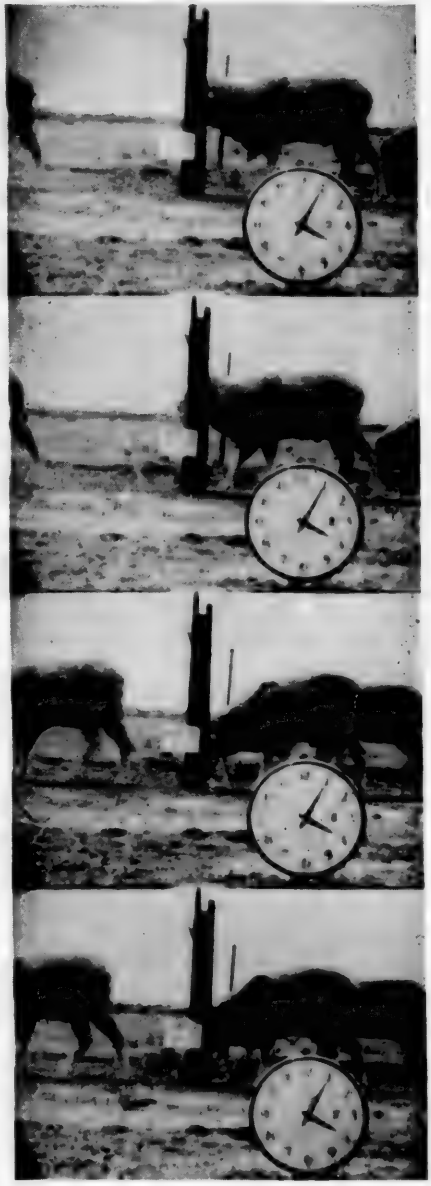


Figure 6 Sequence from Super 8-mm cine film showing movement of individually marked sheep through an automatic recording unit. Note that date, time and place are recorded. Kodachrome II film was used.

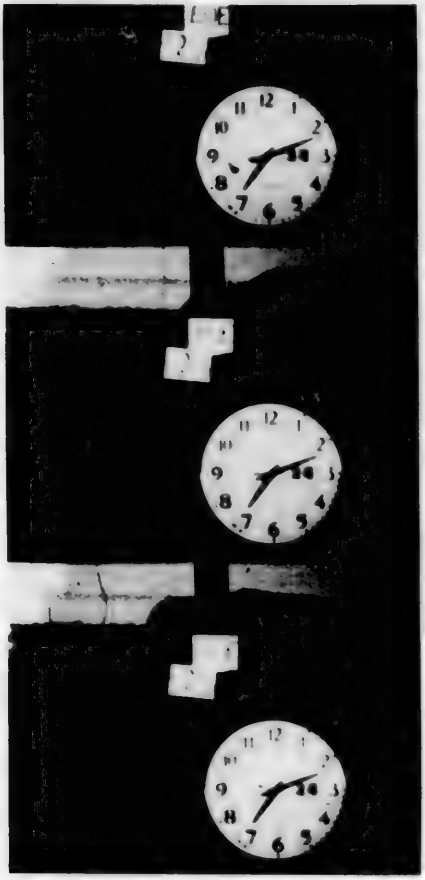


Figure 7 Sequence from Super 8 cine film on Kodachrome II Type A, exposed for 1/20 sec, 12 min after sunset.

sunset and before sunrise (Figures 7 and 10). Panchromatic film, though offering greater latitude in exposure, was not commercially available in Australia for Super 8 cameras, but TRI-X reversal film (ASA 160) has since been released. Super 8 provides quite enough definition for picture analysis and perhaps a more widespread use of Super 8 for scientific applications would stimulate an extension of the film stocks available.

Application

Detailed consideration of the results from these studies will be published elsewhere. However, the following are examples of the types of result that can be obtained from the automatic recording technique.

Leader–follower relationship

Social organization is a phenomenon found in nearly all groups of animals that live in herds, packs, or flocks. A leader is an individual which frequently is at the head of a moving column and often initiates new activity. Movement order, therefore, should give a measure of this leadership potential. In Figure 8, *A* is a bar diagram built from film analysis and it gives ranks assigned to 20 sheep. A score was assigned on a 1 to 20 scale depending on movement order on each of six consecutive occasions through the same recorder, the animal first through scoring 20 and the last scoring 1. Scores earned by two individual sheep (Figure 8*B*) show clear differentiation between leaders and followers.

Walking speed

Average walking speeds were calculated from the times individual sheep passed through recorders at known distances along the laneway. An analysis of average walking speeds of the 20 sheep used in the study showed a consistent and significant difference ($P < 0.01$) between the average speed at which the animals moved to water (1.54 mph) and the speed on the return trip (1.36 mph).

Temporal patterns of activity

The automatic recorders provided information on ingestive and activity behavior, two of the five main types described in Hafez and Scott (1962). The

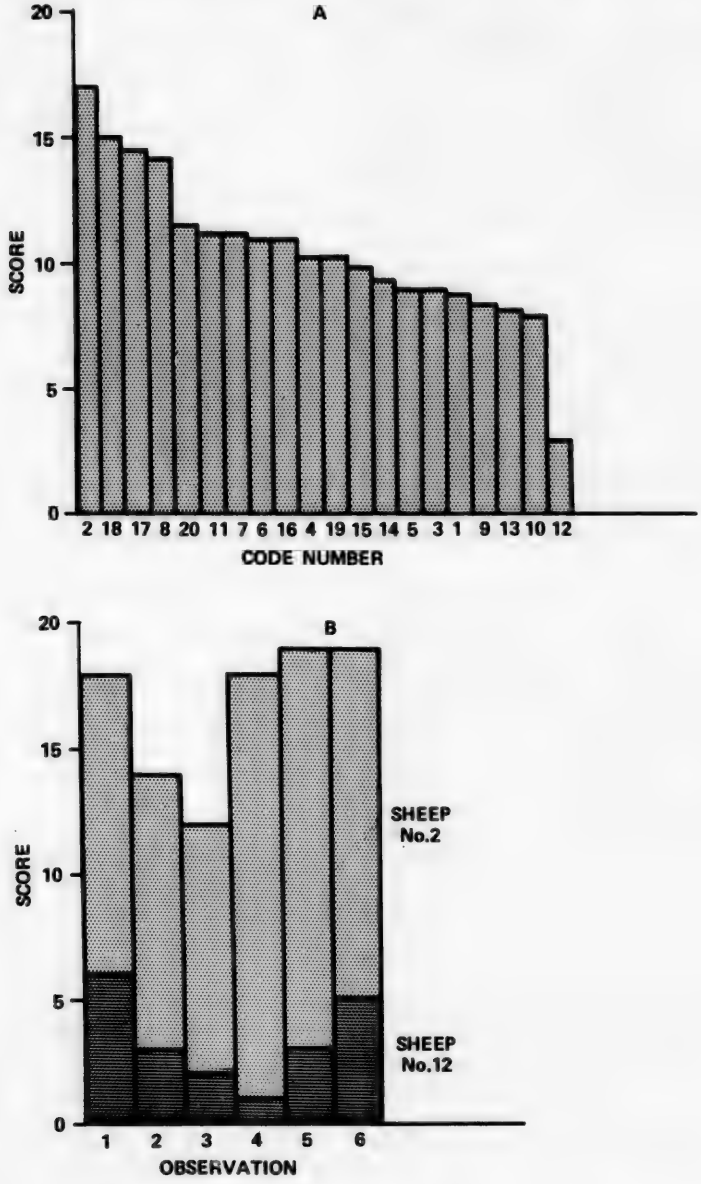


Figure 8 Movement orders: *A*, average score assigned to twenty individually numbered sheep (mean of six observations); *B*, scores assigned to two selected sheep on six consecutive observations.

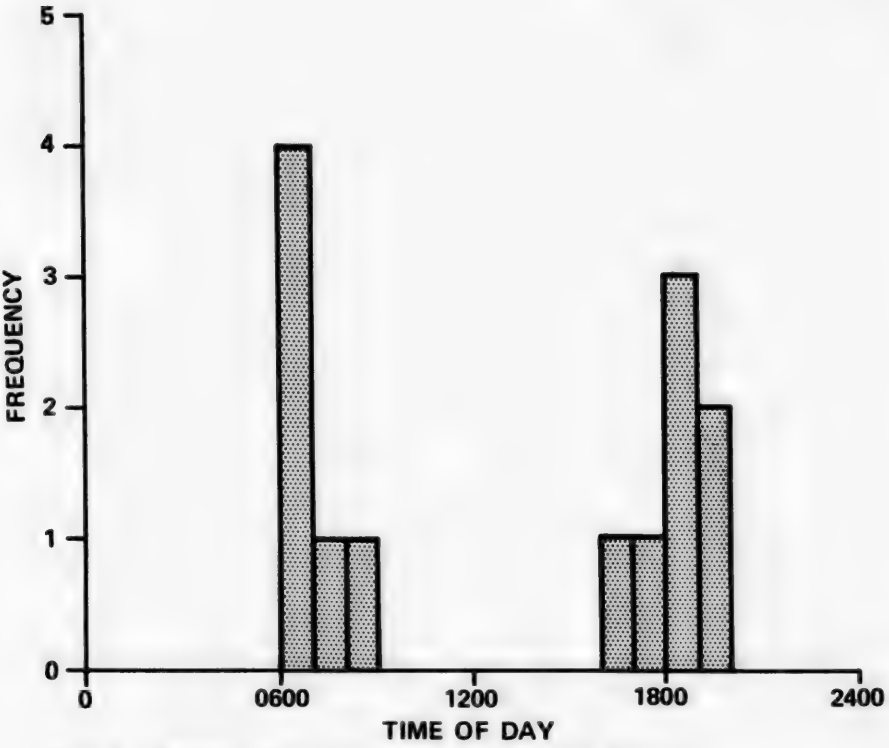


Figure 9 Drinking pattern of twenty sheep over a six-day period.

time spent by sheep each day in walking, feeding, drinking, and resting was determined from the film records. The frequency of drinking was accurately assessed and typical results are shown in Figure 9.

Discussion

The technique allowed several behavior patterns to be recorded. Some of these patterns were of short duration, measured in minutes, whereas others were measured in days. It is because of the extremes of time that these patterns previously received little attention in studies where gross observational procedures were used (see reviews by Hafez and Scott, 1962; McBride and others, 1968).

In the present study the subjects were sheep. There is, however, no reason why the unit could not be modified to record the movement of other animals such as goats and cows or, indeed, why it should be confined to domestic animals. Ealey (1967) used automatic counting devices in his study of the behavior, movements, and drinking patterns in euro, a species of kangaroo. A unit such as the one described here could possibly yield additional information (see Figure 10) in similar situations where some restriction in movement, such as that around water holes and feed troughs, can be tolerated. An alternative triggering device activated, for example, by photoelectric cell could extend its application.

The results presented indicate that an automated method can yield data of considerable value to animal behaviorists. The data are in the form of charts and film, which provide a permanent record. Such documentation gives unbiased recordings of events and has the added advantage of verification of measurements by repetition of the analysis. The disadvantages inherent in film analysis and data processing are probably no greater than those incurred with visual observation procedures.

Acknowledgments

This work was supported by the Australian Pastoral Research Trust. The authors wish to thank the following people for assistance with this project: Dr A. D. Wilson, Commonwealth Scientific and Industrial Research Organization, Deniliquin, for helpful advice in planning; Mr. H. G. Baas Becking, CSIRO, Canberra, for the preparation of the figures; Mr C. J. Totterdell, CSIRO, Canberra, for the photographs; and to colleagues within the Division of Plant Industry for criticism of the manuscript.

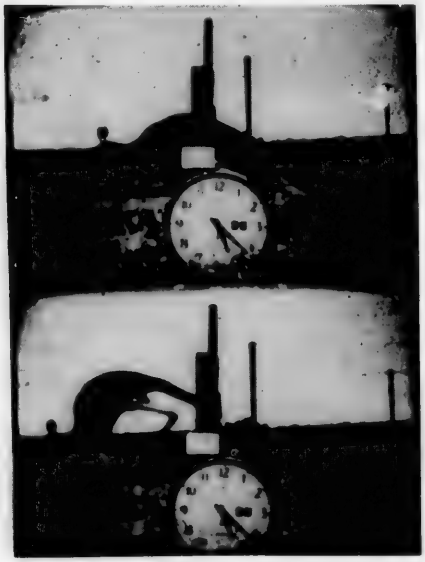


Figure 10 Sequence from Super 8 cine film on Kodachrome II, showing kangaroo activating the recorder 15 minutes before sunrise.

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Photomicrography of bacterial colonies in roll tubes

HOWARD R. ATTEBERY and SYDNEY M. FINEGOLD

Roll tubes are special test tubes that have a solidified nutrient medium in a thin layer on the inner surface. Esmarch (1886) devised the roll-tube method for isolation and enumeration of bacteria and showed the first illustration of a roll tube (Figure 1). These roll tubes were made by inoculating bacteria into a warm sterile liquid gelatin medium in a test tube. A rubber stopper was fitted into the opening and the tube was rotated in the hands. As the gelatin cooled it hardened on the glass surface. Esmarch adapted his roll tubes for the isolation of anaerobic bacteria by filling the central space with a core of sterile agar.

Another method for the culture of anaerobes (Fränkel, 1888) consisted of inoculating a tube of liquid gelatin medium and then sealing the tube with a rubber stopper fitted with two gas lines (Figure 2). A stream of hydrogen gas was passed through the right line; the gas bubbled through the medium and flowed out through the left line. When all the air had been replaced by hydrogen, the glass lines were sealed by heat and the tube rolled. The roll-tube method for the cultivation of anaerobes was modified to include alternate evacuation and replacement with hydrogen gas (Ewell, 1897). Roll-tube methods were reviewed by Frankland (1894).

Roll-tube methods fell into disuse when the Petri dish was found to be superior and more convenient for cultivating aerobic organisms. However, still surviving today is a standard roll-tube method for counting aerobic bacteria in milk (American Public Health Association, 1967). Use of the roll tube is now increasing because of a roll-tube method (Hungate, 1950; Moore, 1966) that offers the advantage of an immediate and constant anaerobic environment. Inocula can be placed into a tube that is already oxygen-free and can be maintained in that condition by a flow of oxygen-free carbon dioxide or nitrogen gas.

The tube can be rolled to coat the inner glass surface with culture medium so that colonies developing within the thin agar layer can be studied and photographed over periods of time with no interruption of the gaseous environment. Roll tubes provide a unique advantage for the continuous study and photography of anaerobes. Not only can colony growth and microstructure be observed, but also such phenomena as dissociation, hemolysis, and inhibition.

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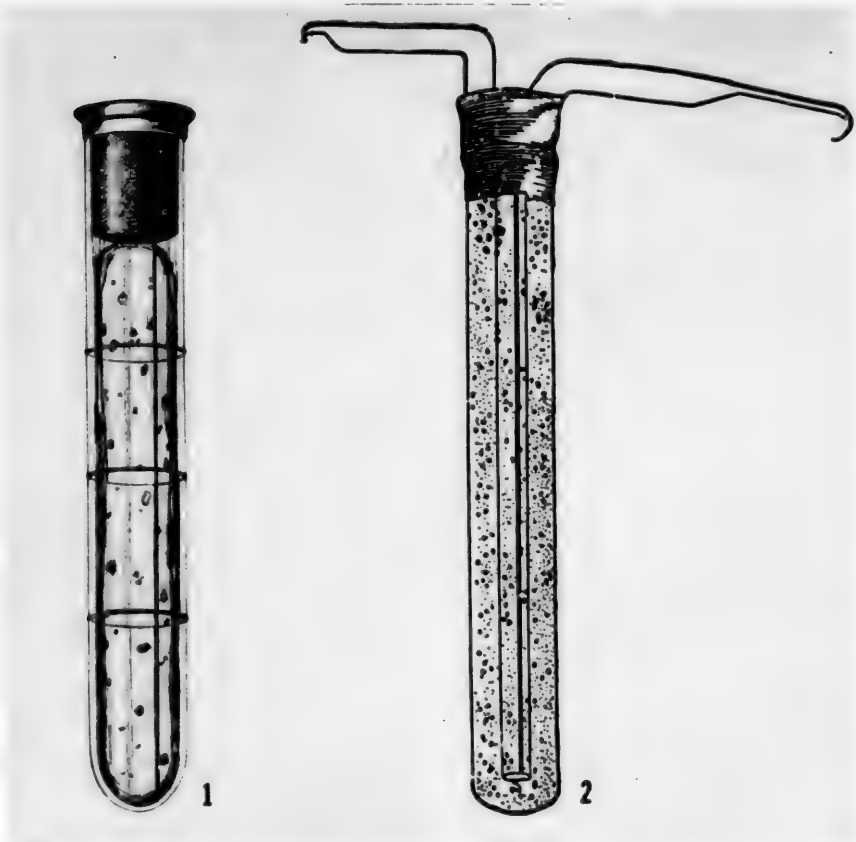


Figure 1 Esmarch's roll tube, showing longitudinal and circular lines drawn on the tube to facilitate the counting of the colonies. (Esmarch, 1886)

Figure 2 Fränkel anaerobic roll tube, showing glass tubing sealed after the medium has been flushed with hydrogen. (Frankland, 1894)

Roll tubes are being used for the cultivation of the normal anaerobic flora and pathogens of man and domestic and experimental animals, and for the simulation of the gaseous environment of other planets in preparation for the material that will be returned by space probes.

Cross and longitudinal sections of the roll tube are shown in Figure 3. The glass wall and culture medium are each 1 mm thick. The outside diameter is 13.8 mm. The bacteria are uniformly seeded throughout the nutritive medium. Growth may take place at the agar-gas surface, within the agar, at the glass-agar interface, or at more than one of these areas. The colonies to be photographed are usually 0.1 to 5 mm in diameter, and the required photographic film magnifica-

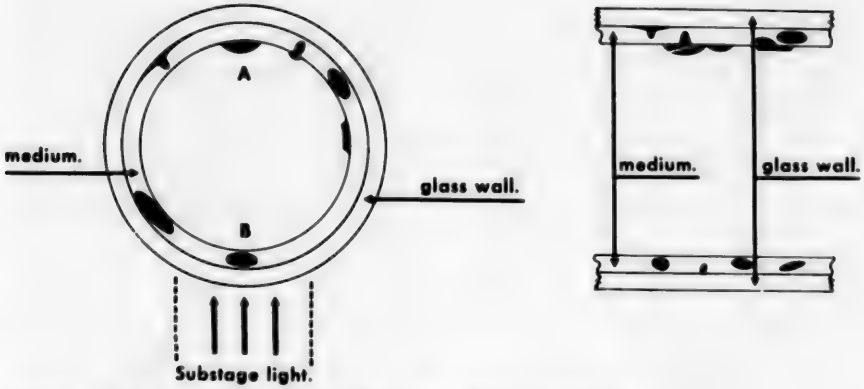


Figure 3 Roll tube: *left*, cross section; *right*, longitudinal section

tion ranges from 1:1 to about 150:1. Photomacrography would be suitable for the lower part of this range; however, we use the laboratory's existing photomicrographic equipment.

For routine low-power roll-tube microscopy, we use a Bausch & Lomb wide-field stereoscopic binocular or Greenough-type microscope mounted on a plastic electronic chassis (Figure 4). This box contains a 40-watt wound-tungsten-filament, screw-base, miniature bulb that utilizes 110 volts. The light is diffused by a finely ground, glass disk. Light intensity is regulated by a rheostat. The heat produced by prolonged use of the light is dissipated by using a small electric blower installed in the box. The light can also be adjusted to off-center position or placed at various distances from the roll tube.

The hardwood stage was specially made. It was machined with a groove, which allows a roll tube to be so placed that it is perpendicular to the vertical axis of symmetry of the microscope and is centered as well as parallel to the rod, which is the attachment site for a simple micromanipulator.

If the tube is to be photographed and then discarded, it can be photographed in any position. However, if photography is done before the microbiologist has finished his experimental work, the tube must be handled in a special way. The reason for this care in handling is that roll tubes contain water of condensation and syneresis, which is normally at the base since the tubes are incubated with the base down. If this water is allowed to spread to other parts of the tube it can carry organisms with it, and subsequent growth of these organisms in undesirable locations will make further photography or microbiological procedures useless. So that the moisture will remain at the base, the tube must be handled with the base always lowermost. The microscope is tilted to allow the tube to be photographed with the base in this position. Tape or small bags containing lead shot are used to hold the tube to the stage.

For photomicrography, a Miranda D camera (Figure 4) with a through-the-lens cadmium sulfide exposure meter was attached to one of the oculars of a bin-

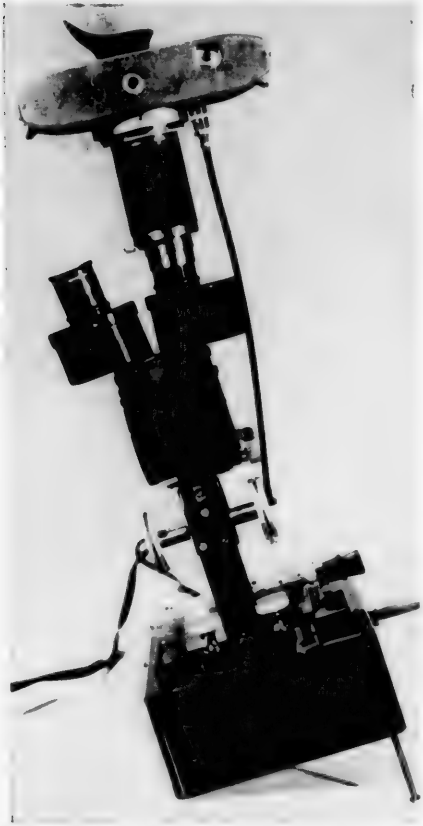


Figure 4 Low-power roll-tube photomicrographic equipment, showing microscope tilted to keep the water at the bottom of the tube.

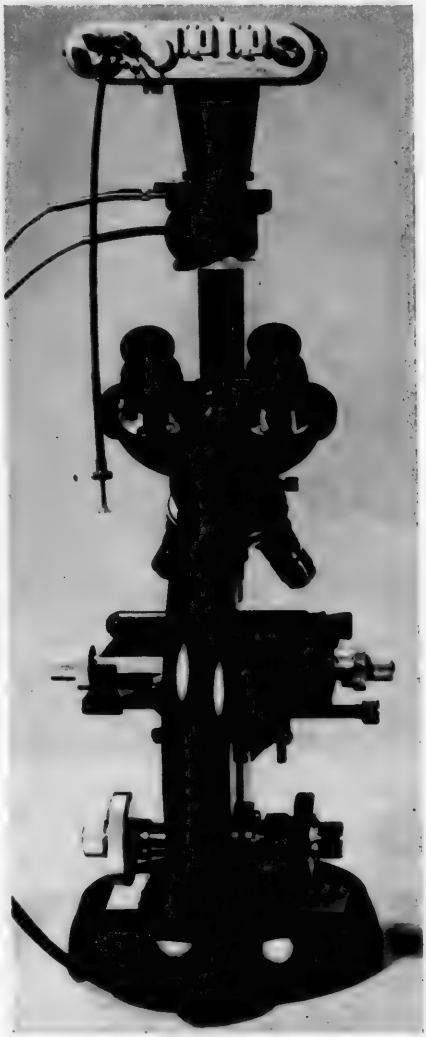


Figure 5 High-power roll-tube photomicrographic equipment.

ocular microscope. The attachment was made by means of a tube, which supports the camera. The film plane is 5 inches above the ocular. With a ×15 ocular and objectives ×0.7, ×1.5, and ×2, enlargements of ×5, ×9, and ×12 are obtained on the film. Photographing through one lens system of the binocular microscope at a low power of ×5 to ×12 at the film plane is usually done with this microscope as it is used for the routine examination and counting of roll-tube colonies. Colony types, gross colony structure, and phenomena of colony–medium interaction can be satisfactorily photographed in color and black and white. However, the Greenough-type microscope is gen-

erally unsuitable for high-magnification photomicrography (Needham, 1958), because: it has no ready means of stopping down the objective, the train of prisms in the body tube are not conducive to crisp definition, and the object plane is not horizontal. The reason the object plane is not horizontal is that the binocular lens systems are divergent, each approximately 5° to the mechanical axis of symmetry. In photographing through one lens system, when the tube is correctly placed horizontally for stereoscopic viewing it is 5° from perpendicular to the optical axis. To bring the tube perpendicular to the optical axis, a 5° shim can be placed in the roll-tube stage groove. This is not necessary for low-power photomicrography because the depth of field is adequate to keep a colony entirely in focus, but at higher magnifications one side of the field will be out of focus.

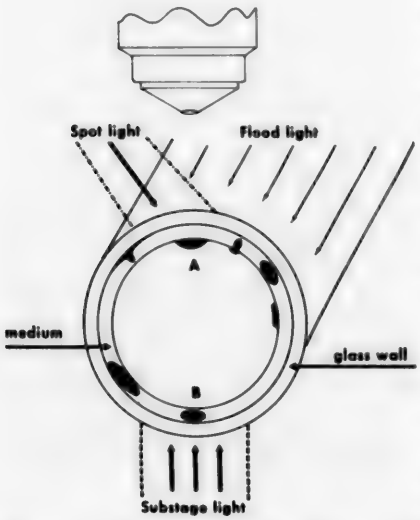


Figure 6 Roll-tube lighting, showing tube in cross section.

For photographs at a magnification higher than 12, we use a Zeiss GFL trinocular scope (Figure 5). The light is an 8-v, 15-watt bulb, and the illumination system is designed according to Köhler's principle. However, because of the nature of the roll-tube, actual Köhler illumination cannot be achieved. A Mikas attachment used with the Leica 1G camera reduces the ocular image to one-third. A ×10 Leitz periplan ocular and Zeiss planachromatic objectives 2.5/0.08, 10/0.22, 40/0.65 give enlargments at the film plane of ×8, ×33, and ×133. Exposure is determined with a Photovolt electronic photometer, Model 501-M.

Photographing small objects within a pyrex glass walled tube presents some problems. What is actually being done is photographing a subject that is within a lens system. If a colony is photographed at position *A* in Figure 6, three difficulties are present: the lens effect of the cylindrical surface, defects in the glass wall, and the 1-mm thickness of the glass wall. If the same colony is photographed at position *B*, distortion is greater because the effect of the tube's lens is more pronounced at the greater distance from the object. In this case, the cylindrical wall of the tube is closer to the objective lens of the microscope, and therefore the wall tends to become a greater part of the image-forming system.

The colony in Figure 7, *left*, was photographed at the top position (Figure 6, *A*). The same colony (Figure 7, *right*) was photographed at the bottom position (Figure 6, *B*). The colony appears compressed when it is photographed at the lower position. The protraction is along the long axis of the tube. Photographing at the top position gives a more accurate reproduction of

the colony than photographing at the bottom position. This statement has been proved by observation of perfectly circular disks after they have been placed within the roll tube. The reason for the compressed appearance is that the lens effect of the cylindrical glass surface is practically at the object plane. Therefore, its lens power is minimal with respect to the microscope objective. Both exposures in Figure 7 were made at 1/4 sec. The right picture shows the increased light at the bottom. This increase is caused by the fairly close proximity of the objective to the light source. The cylindrical surface of the tube results in distortion in the lighting system as well as in the viewing system. To see if a modeling effect could be produced, and if it would be advantageous, the substage light was off-centered. No advantage was obtained in the case of the opaque colony pictured in Figure 7, but there would likely have been an advantage if translucent colonies had been photographed.

Different lighting methods were tried alone and in various combinations. Not only was a 40-watt substage lamp tried, but a 40-watt spot, a 100-watt flood, and a 60-watt high-intensity flood light were also used. A microscope lamp with a collector lens was used as a spot. Some of the various light placements are shown in Figure 6.

For evaluating the different lighting conditions, we used Tri-X film developed in Acufine. Our observations throughout this study indicate that for revealing colony detail and microstructure, transmitted light is generally superior to reflected light and combinations of reflected and transmitted light.

The colony shown in Figure 8 is illuminated by substage transmitted light. When this light is used, there is often enough light striking the walls of the roll tube and reflected from them to give an appearance of depth. This colony is growing within the agar and the background is the agar–gas interface. The pods of the crenate margin at the

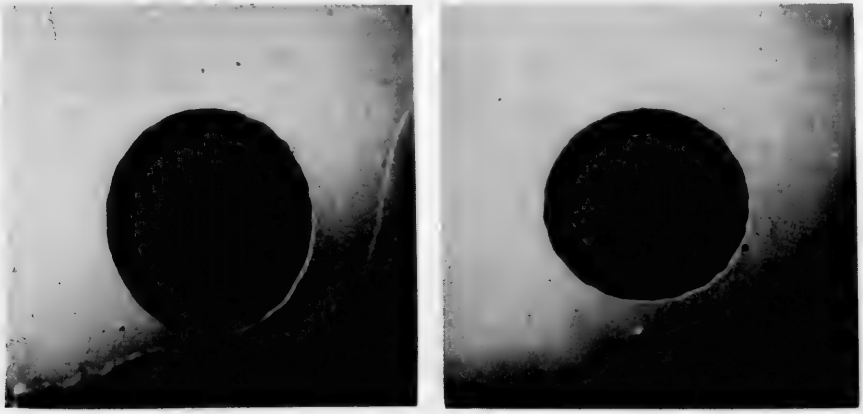


Figure 7 *Bacteroides melaninogenicus* colony photographed at (*left*) top position, and the same colony (*right*) after being moved to bottom position within the tube. Because the long axis of the tube is horizontal, the "lens effect" of the tube makes the colony appear compressed when it is photographed at the lower position in the tube.

lower right are starting to grow out of the agar into the gas space on the other "side" of the agar.

A word of caution concerning photographing roll tubes is needed. The medium can sweat easily from the heat of incandescent lamps. Though the sweat is temporary, the heat that produces the droplets (Figure 9) may be damaging to further colony development.

We have been interested in the colony development of *Bacteroides melaninogenicus*, a member of the normal oral and fecal flora of man, and also a pathogen implicated in gingival disease and serious human infections. The tube on the left in Figure 10 is an uninoculated roll tube containing laked blood agar medium. The tube on the right was seeded with the organism and the culture incubated 20 days at 37° C. The picture shows that the blood pigment has been utilized and transferred to the developing colony. After 7 days, pigmentation is seen to be present in good amount (Figure 11, *left*) and the medium is clearing. In hemolysis recording, it is important to have even lighting. There is no sharp zone of hemolysis with this species. The zoning can be seen in the original transparency, but it is not reproduced when the transparency is converted into a black-and-white print or when it is reproduced by any other method. The middle photograph of Figure 11 shows different types of colonial morphology. The out-of-focus spots are colonies on the opposite "side" of the tube. At the right, an almost pigment-free mutant is shown with normal pigmented colonies. Figure 12 shows the outer un-

Figure 8 Colony photographed with 40-watt substage light only. Enough light is reflected by the interior of tube so that modeling and depth may be appreciated.

Figure 9 Sweat, or small translucent droplets, formed by overheating the medium by prolonged lighting. The larger opaque body is a portion of a colony. The small out-of-focus spot is a colony on the opposite "side" of the tube.

pigmented margin of the developing colony, a darker inner band, and the bulk of the colony with uniformly darker pigmentation. In an attempt to detect banding within the denser part of the colony, a substage condenser of 1.3 NA was used to increase light to the denser area. This method has proved successful in making an area in an otherwise opaque colony translucent by "punching out" a spot with the increased intensity of light. Because no banding was evident within the dense area made translucent by this method, distribution of the pigment must have been homogeneous. Photomicrographs taken with the apparatus shown in Figure 5, with ×10 ocular, ×10 objective, and a ×1/3 Mikas attachment, gave ×33 on the film. Exposures on Ektachrome X required 1/125 sec. At ×33, definition was poor.

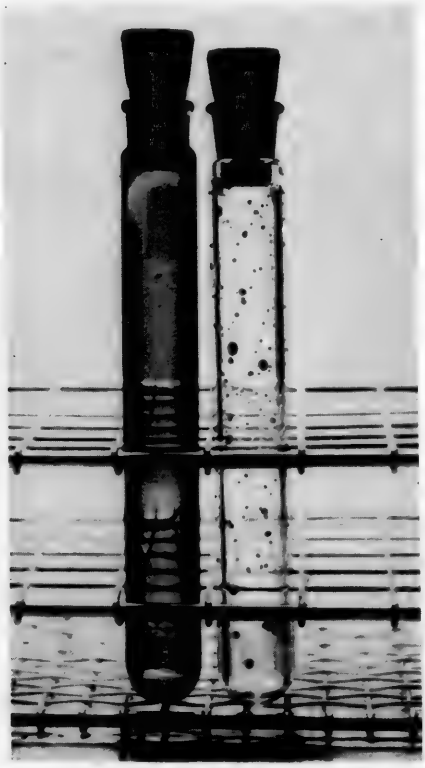


Figure 10 *Left*, tube containing uninoculated laked blood agar. *Right*, tube containing laked blood agar that has been inoculated with *Bacteroides melaninogenicus*, which has transferred the blood pigment from the medium to the developing colonies.

A colony beginning to develop a tail is shown in Figure 13. In this example, some of the cells have been carried downward by gravity. They can proliferate, and begin the process again, and eventually a long tail can be formed. A colony selected from near the glass surface, such as this one, usually provides a photograph that is superior to those obtained of colonies deep in the agar, as defects in the medium are minimized.

Our best results in photomicrography of organisms in a roll tube have been obtained by using transmitted light, centering the colony at the optical axis of the microscope, selecting colonies growing near the glass surface, positioning the tube so that the colony is as close as possible to the objective lens, and selecting colonies that are flat. It is possible that methods and equipment other than those that we used could provide better results. A microscope lens designed specifically for roll-tube work would be very helpful.

The present roll-tube design allows some degree of success with photographic recording, but it does not allow high-quality pictures at magnifications of 30 or greater.

For best results in high-magnification photomicrography of anaerobes, and for improved results at low magnification as well, a cell for the cultivation and subsequent photography of colonies is proposed (Figure 14). It should consist of glass with good optical qualities and be

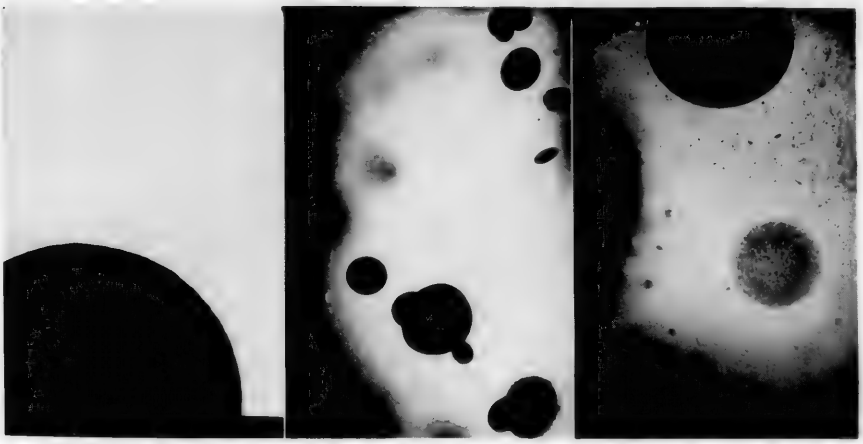


Figure 11 *Bacteroides melaninogenicus*. *Left*, mature colony showing clearing of medium; *middle*, colonies seen as out-of-focus spots on opposite "side" of tube; *right*, unusual colony that is almost devoid of pigment, also normally pigmented colonies.

Figure 12 Colony growing at the glass–agar interface showing light "punch."

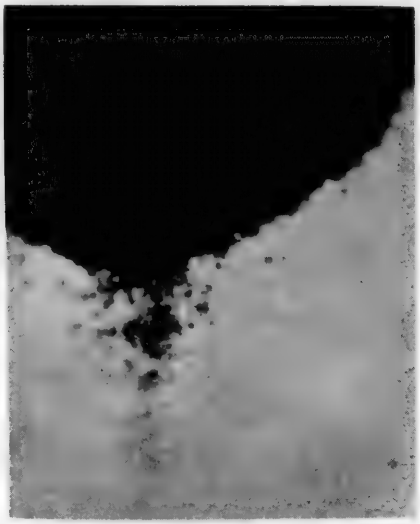
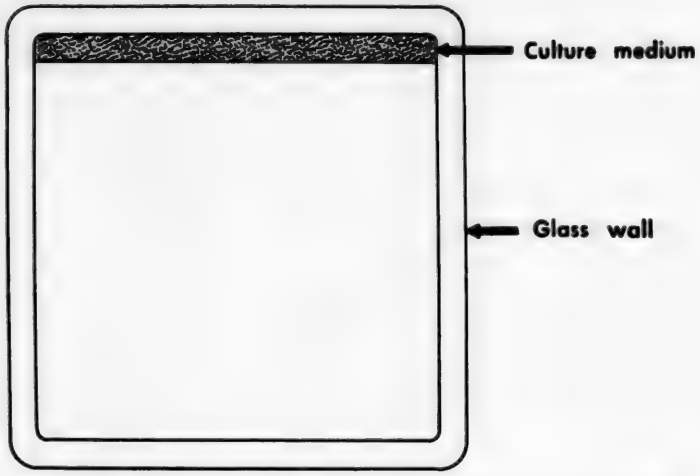


Figure 13 Detail of a colony growing at the glass–agar interface, showing portions of the colony developing downward by force of gravity.

of rectangular shape and of test-tube length. One wall should be thin. If a 40/0.65 objective were used and the tube wall were 0.5 mm thick, microphotographic objects could be registered to a distance of 0.35 mm from the inside glass surface. A thinner wall would be more advantageous, but the cost of manufacture and loss by breakage would increase as thickness decreased.

However, since the conventional roll tube will continue to be the culture vessel most often photographed, this article has been limited to an account of such a type.



Figue 14 Proposed anaerobic culture chamber for photomicrography, seen in cross section.

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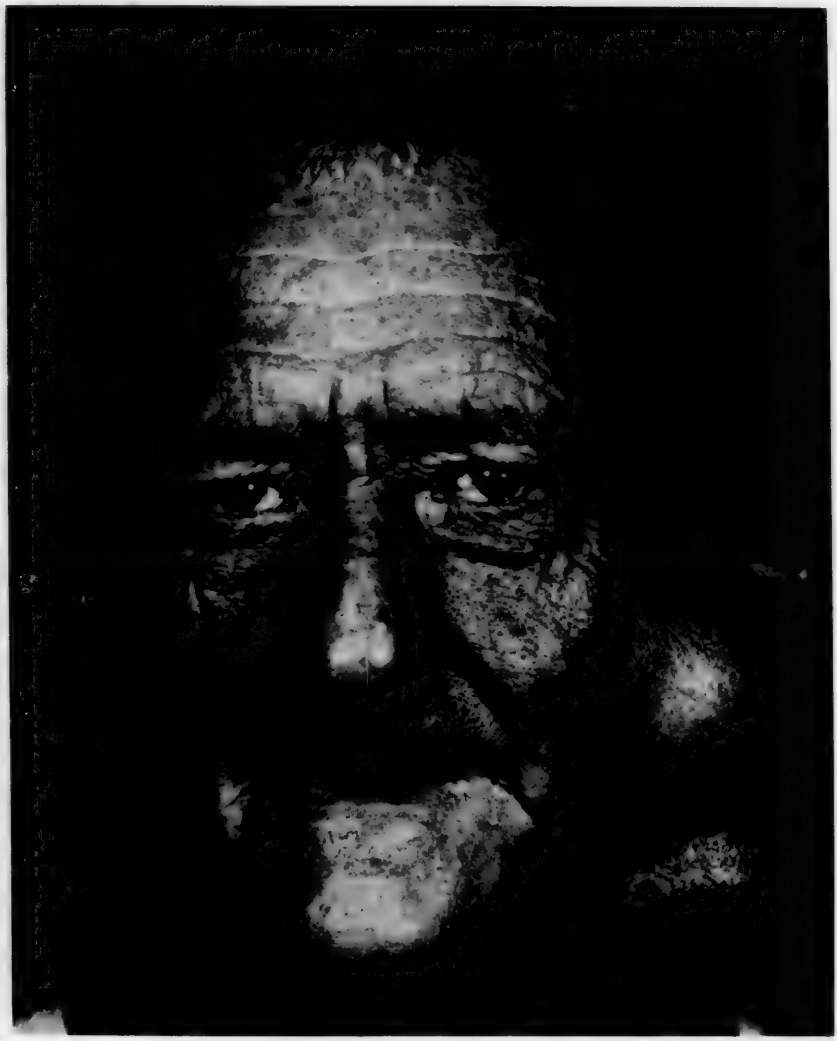
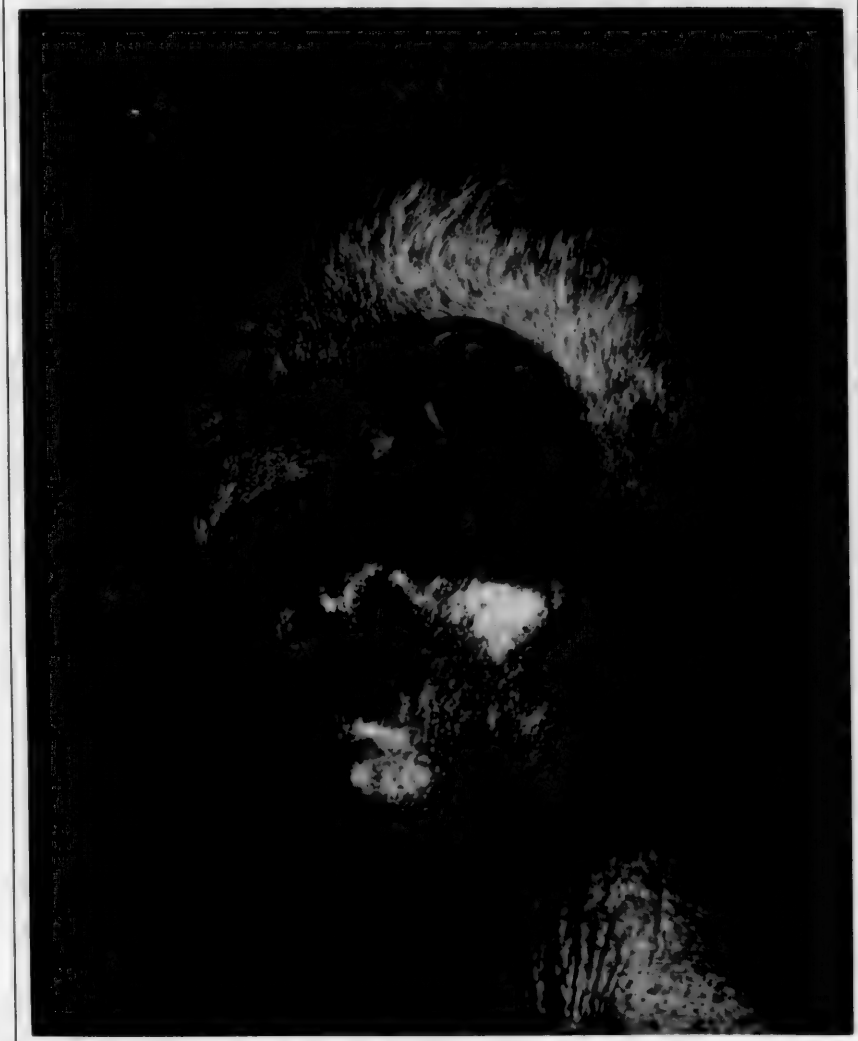


Shirley J. Whaley

Tumor of the parotid gland

These pictures, showing a tumor of the parotid gland, were taken by Shirley J. Whaley, Department of Medical Illustration, Medical College of South Carolina, Charleston, S. C.



Shirley J. Whaley — Tumor of the parotid gland

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TECHNOTES

TWO REVERSAL PROCESSES FOR RAPID SLIDE PRODUCTION WITH CONTINUOUS-TONE AND LINE-COPY FILM

In photography, a reversal process is a method that provides the reverse of the image formed by direct development. In this process the film is exposed in the usual manner and placed in a developer that produces the negative image. At this point the method departs from ordinary negative processing. The film is placed in a dichromate bleach bath, rather than the customary short hypo bath. The bleach bath converts the negative-image silver formed in the first developer to a soluble silver sulfate, which almost completely diffuses from the emulsion into the bleach bath. A water rinse then removes any residual silver sulfate and bleach-bath chemicals from the emulsion. After this rinse, a bath in sodium sulfate or sodium bisulfate removes any residual dichromate that might interfere with the action of the second developer. This rinse is called the clearing bath. After another water rinse the film is given a reversal exposure, which exposes the unexposed silver halide that has remained unchanged. This exposure makes the positive image-to-be. The reexposed film is then developed in a second developer. The film is rinsed in a water bath, and then placed in hypo. In a reversal process almost all the silver halides are exposed and developed. However, a fixing bath is required to remove any trace of them, to neutralize the alkali from the developer, and to harden the gelatin in the emulsion.

With continuous-tone roll film and sheet film

The chemicals used in the following process are normally used with motion-picture film. They are liquid-concentrate cine-reversal solutions made by the FR Corporation, and for use they are diluted 4:1. They are: FR Cine Reversal First Developer CR-1 (Catalog No. 861), Bleach CR-2 (Catalog No. 862), Clearing Bath CR-3 (Catalog No. 863), and Second Developer CR-4 (Catalogue No. 864). These chemicals come in a 5-quart concentrate container. Conventional hypo is used for the fixing bath.

The film that gave consistently best results was Kodak Panatomic-X in 120 (Figure 1) and 35-mm (Figure 2). Table 1 lists other roll and sheet films tried in this process.

The processing times for the FR cine-reversal chemicals diluted 4:1 at 68° F are as follows: First developer, 4 min development time, agitating constantly during the first full minute then agitating every 15 sec during the remaining 3 min. Water rinse for 30 sec. Bleach for 1 min, with constant agitation. After 30 sec in the bleach an OA safelight may be turned on. Water rinse for 30 sec. Place the film in the clearing bath for 1 min and agitate constantly. Rinse the film again for 30 sec. After the film is placed in the water rinse, the room lights may be turned on for the remainder of the process. Give the film

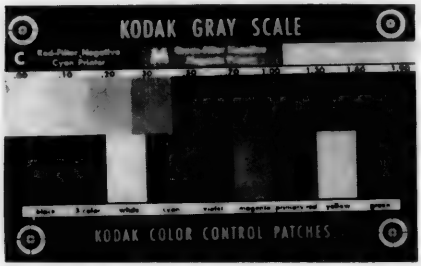

Figure 1 Kodak Panatomic-X 120 frame that was processed in the reversal process.

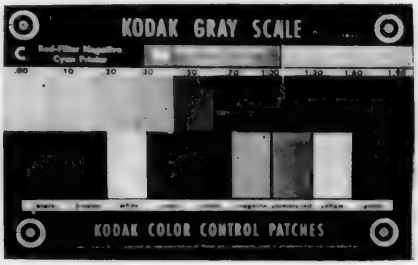

Figure 2 Kodak Panatomic-X 35-mm frame that was processed in the reversal process.

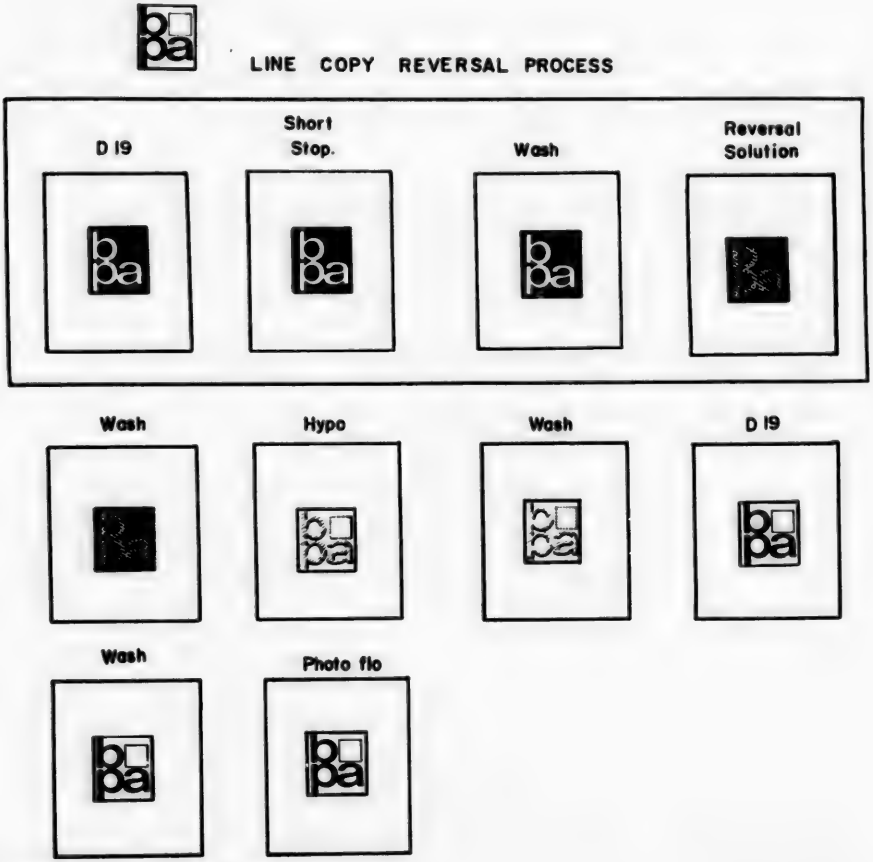

Figure 3 Steps in the line-copy process.

a reversal exposure of 30 sec to each side of the reel. After this exposure place the film into the second developer for 1 min and agitate constantly.

Rinse the film, place it in the hypo for approximately 1 min, and then wash it for 2 min. Place it in a wetting agent such as Photoflo and hang it to dry. The total processing time is about 13 min. The first and second developer should be mixed according to the amount needed to develop the film. It can only be used for 3 to 5 days. The bleach and clearing bath have much longer life.

In exposing the film it is necessary to crop in the camera, leaving on the film what is needed to be shown on the screen. In our unit we use a single-lens reflex for 35-mm slides. For the $3\frac{1}{4} \times 4$ slides we use Number 120 rolls and a Graflok back. The Graflok back is used with a piece of opaque black Plexiglas, which, fitted to both the 5×7 and 8×10 cameras, gives flexibility on any copy of photo. We crop by placing a mask on the ground glass.

With line-copy sheet film

The line-copy reversal process (Figure 3) is different from the continuous-tone method. Except for the normal line-copy processing developer and hypo, only one

Table 1. Results of films used in the reversal process

Kodak Roll Films	A.S.A.*	*Results*
Tri-X Pan, 120	200	Poor
Plus-X Pan Professional, 120	40	Poor
Plus-X Pan, 120	40	Poor
Panatomic-X, 135, 120	100	Excellent
Verichrome Pan, 120	250	Very good
Royal-X Pan, 120	500	Very poor
High Contrast Copy	—	Very poor
Direct Positive 35-mm	100	Excellent
Kodak Sheet Film		
LS Pan	2.5	Fair
Panatomic-X	2.5	Fair
Plus-X Pan	1.5	Good
Tri-X Pan	125	Good
Contrast Process Ortho	32	Very good
Kodalith Ortho, Type 3**	16	Very good
Gravure Copy***	80	Excellent
Fine Grain Positive	0.5	Excellent
Dupont Sheet Film		
Cronar Ortho Litho A	16	Excellent

*Experimental only.
**Can be used for both line and continuous-tone copy.
***A.S.A. 125 with continuous-tone copy.

chemical is used. The film is Kodak Kodalith Royal Ortho sheet film at ASA 20 and the chemical to produce the reversal solution is Modi-Graphic reversal solution mixed 1:1 with 3% hydrogen peroxide. In combination, the chemicals are blue green, the normal color when mixed. We develop the line-copy negative in Kodak Developer D-19, under a Kodak Safelight Filter Series 1A, to its normal density. After being in the short stop for 30 sec the film is placed in a rinse for approximately 30 sec, and then placed in the reversal solution. At this point the room lights may be turned on. The reversal solution removes the black, or exposed, silver from the negative, leaving a pink opaque negative-like image. The film is then rinsed to remove the reversal solution, and placed in the hypo, where the pink opaque background quickly fades. This change takes place very rapidly in fresh hypo, and care must be taken not to remove the future positive image, which might also clear and leave a blank film. The film is then washed to remove the hypo, and again placed in the developer to develop the lettering to an opaque black positive image. A second fixing bath is not needed. The film is again washed and then placed in a wetting agent before being dried. We can shoot for either 35-mm or $3\frac{1}{4} \times 4$ slides by cropping in the camera, as described in the continuous-tone process.

Color can be added to the lettering or the chart image by clearing the film completely when it is in the hypo. Only a gelatin image remains. The film is washed to remove the hypo and then Kodak Flexichrome Colors are applied with cotton swabs on the raised or etched side of the film. Any excess color can be removed from the background by using a cotton swab soaked with acetic acid. Care must be taken not to rub too hard or the color will be removed from the lettering as well. The films are then rinsed, dried, and mounted. The lettering should be fairly large, because the colors will not hold on small print.

The author would like to thank Mr. J. Robert Dant, Chief, Medical Illustration Service, Veterans Administration Hospital, Augusta, Georgia, for his help in obtaining the film ratings shown in Table 1.

THOMAS W. LANIER
Instructor, Medical Illustration
Medical College of Georgia
Augusta, Ga. 30902

Received 26 March 1969

CAROUSEL SECURITY BRACKET

Until recently, slide projectors have remained permanently in each of our three main classrooms. These machines were available for use by anyone. They were always ready for operation, focused, and provided with spare bulbs. However, a theft made it necessary to find a way of preventing the projectors from being taken away.

New Carousel projectors were bought to replace the stolen equipment. In order to lock the projectors in place, yet allow for a change of bulbs, we constructed a hinged metal strap, which is in effect an elongated hasp (Figure 1). A lock through the staple secures the bracket (Figure 2). The apparatus can easily be inverted to allow access to the lamphouse.

Our engineering department made the bracket from strap steel according to our cardboard pattern.

Figure 1 One projector inverted, to show the bracket, and another in normal position.

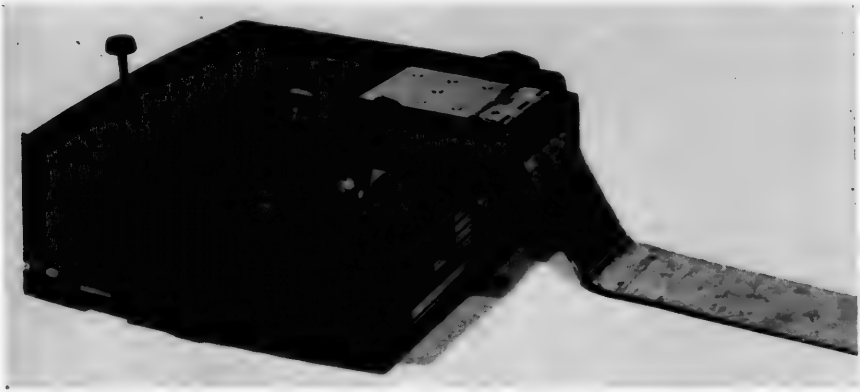

Figure 2 Detail of bracket construction, also showing easy access to the lamphouse.

NICHOLAS M. GRAVER, RBP
University of Rochester
School of Medicine and Dentistry
Rochester, N. Y. 14620

Received 20 August 1969

ROLL-FILM DRYER

The answer to a need for a dust-free place in which to dry 36-exposure rolls of 35-mm film was provided by a single wall locker (Figure 1). It is 7 ft high and requires only 16 × 16 inches of floor space. An exhaust fan mounted in the top generates a good flow of air. The upper door vents are sealed with tape. Filter material of the type used in air conditioners covers the lower vents in the door. A 500-w electric heating element with a splash shield over it was placed in the bottom.

Figure 1 The roll-film dryer, which was converted from a wall locker.

The cabinet handles all our roll films and dries them quickly. The temperature never exceeds 110°, which is the limit for color film. We find it better in many respects than our $600 commercial dryer, which is now permanently fitted with sheet-film racks. Several visitors have shown interest in this locker dryer and they have gone home to build their own.

NICHOLAS M. GRAVER, RBP
Chief of Medical Photography
University of Rochester
School of Medicine and Dentistry
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Received 20 August 1969

SHOPTALK

in medicine

COPYING MEDICAL X RAYS

Medical photographers are often asked to make lantern slides and prints from copy negatives of X-ray photographs. Although the copying procedure is fairly routine, the results are often unsatisfactory. It is hoped that the following suggestions for copying X rays by means of conventional equipment will make the results consistently good.

The X rays to be copied must be good in every respect. The type of camera does not matter, although I find the 4 × 5 view camera, equipped with normal, wide-angle and long-focus lenses, to be best for most copy requirements. If slides are to be made, it is well to outline the size of the image on the ground glass of the camera. A grease pencil should be used to trace around a standard slide mask.

Best results are obtained by using an aperture about two stops above the smallest. No complex formula for computing the bellows factor is needed, and the photographer does not have to use lengthy tables for the various lenses. A simple method to establish the effective *f* stop is to multiply the *f* stop indicated by the light meter by the focal length of the lens (in inches) and divide by the lens-to-film distance (bellows extension, also in inches). A simpler method is to add 1 to the scale of the negative and multiply the total by itself. As an example of the second method, if the scale of the negative is 1, the bellows factor is 1 plus 1, or 2, multiplied by 2, which equals 4.

A standard X-ray viewer is quite satisfactory as an illuminator.

As with any other type of photography, selection of a suitable emulsion cannot be overemphasized. Slow-speed orthochromatic or panchromatic film is recommended.

To avoid loss of essential detail in the middle tones, a meter reading should be taken of both the high- and low-density areas of the film. The meter is then set at a point midway between these two readings and the exposure calculated from this setting. Then the compensation for the bellows extension is determined. The resulting negative will yield good slides and prints by either contact or enlargement printing, without any excessive dodging and burning-in to preserve essential details in the finished visual.

Since slides are viewed under strong illumination, it is usually not hard to produce a satisfactory slide from a wide range of negatives. However, a print is viewed by light reflected from the paper base and the light striking the surface.

This often results in loss of essential detail in the finished print, but it is not nearly so apparent in a slide prepared from the same negative. Consequently, each negative must be so exposed as to render the best possible print.

V. A. Veach
817 W. Galena Blvd.
Aurora, Ill. 60506

Received 28 April 1969

letters to the editor

Phase contrast — author's answer

Concerning the comment of Doctor George J. Anday [*Journal*, July 1969] about my paper in the first issue of 1969, he is quite correct that phase contrast enhances contrast and not resolution.

That resolution between points is sadly deficient in my in vivo unstained material, which is visualized, as in macroscopy, only by the light that the object reflects, and which does not make use of the differentiation by diffraction that is so elegantly done by phase contrast or in any transmitted illumination.

Charles L. Schneider, PhD, MD
Associate Professor Obstetrics and Gynecology
The University of Michigan
Wayne County General Hospital
Eloise, Michigan 48132

book reviews

Photographic Sensitometry — The Study of Tone Reproduction

By Hollis N. Todd and Richard D. Zakia. Morgan and Morgan, Inc., 400 Warburton Avenue, Hastings-on-Hudson, N.Y. 10706. 1969. 320 p. $9.95.

Any professional photographer, whether biological or otherwise, will welcome this concise (320 pages, $5\frac{3}{4} \times 8\frac{1}{2}$ inches) book on practical methods of process control, based on easily understood statistical methods; microsensitometry; color as well as black-and-white; and the psychological as well as physical aspects of modern photography. The contents, in 13 chapters, include discussion of such timely topics as tone reproduction, characteristics of light and light sources, sensitometric test methods, exposure effects, processing effects and processing methods, film speed and special sensitivity, density measurements, and sensitometry of color photography.

The authors of this book, H. N. Todd and R. D. Zakia, professors at the School of Photographic Arts and Sciences, Rochester Institute of Technology, are well known for the many articles they have contributed, jointly and separately, to various photographic journals. They have also written chapters for Prof. Neblette's *Materials and Processes of Photography*, and for *Colliers' Encyclopedia*.

The advanced approach in writing this book, based on many years of teaching experience, emphasizes clarity of communication for individual study and class textbook use. It is readily understandable to professional photographers, engineers, technicians and laboratory personnel.

S. K.

Light Through the Lens

By H. Lou Gibson. Christopher Publishing House, N. Quincy, Mass. 1968. 123 p.

This is a very personal book that can mean much to different people. There are many superb pictures, some with related poetry; some pictures speak for themselves and other poetry nourishes the mind. The publisher commends it to teachers of English, Art, Speech, and Drama, and to others contemplating the human universe. Gibson says: "This book offers an experiment made by the author to explore the proposition that poetry can be written in photographic silver as well as in ink." The selections from work of many years adequately demonstrate a successful experiment and provide challenge to all photographers. This delightful work spreads a radiance in a presently troubled world. Why not more quality pictures and less exposure of poor pictures? Living organisms are here photographed artistically, yet they have the necessary detail for biological use. Thank you, Lou, for sharing your triumphs with us! Now a poet should review the other content of this fine little volume.

Prospectus

Biocommunications 70

The combined annual meetings of the

Biological Photographic Association, Inc.

and the

Association of Medical Illustrators

with the participation of the

Council on Medical Television

Houston, Texas

9-12 August 1970

BIOCOMMUNICATIONS 70 will combine the 40th Annual Meeting of the Biological Photographic Association, Inc., the 25th Annual Meeting of the Association of Medical Illustrators, and the participation of the Council on Medical Television. These three groups will be meeting together for the first time to explore practical methods of improving medical and biological education through improved audiovisual techniques.

The technical program of BIOCOMMUNICATIONS 70 will emphasize application of a multi-disciplinary approach to the challenges facing the biocommunicator today. Combined sessions will explore areas of overlapping interests and separate meetings will deal with more specialized aspects of the individual associations. Concurrent specialized sessions will include small discussion groups and mini-workshops geared to individual levels of proficiency. Scheduling of films and videotapes will afford multiple opportunities for viewing during the course of the meeting. An expanded commercial exhibit program will provide valuable information about equipment and materials available to the biocommunicator today.

Houston is a growing, dynamic city with many interesting activities to offer its visitors. There will be tours and other events planned to accommodate the families of those who attend BIOCOMMUNICATIONS 70 on their vacation.

For further information: Herbert R. Smith, Jr.
General Coordinating Chairman
Biocommunications 70
Baylor College of Medicine, Room 414E.
Texas Medical Center, Houston, Texas 77025

3-9 AUGUST 1970

Pre-meeting Refresher Courses and Business Meetings

SUNDAY, 9 AUGUST 1970

1:00- 5:30 p.m. Registration

6:00- 9:00 p.m. Reception and Official Opening of Exhibits

MONDAY, 10 AUGUST 1970

9:00-10:00 a.m. BPA Scientific Session, AMI Business Meeting
Film and Videotape Viewing

10:00-10:30 a.m. Intermission: To view Exhibits & Coffee Break

10:30-12:00 noon BPA & AMI Scientific Sessions, CMT Television Workshop

12:00- 1:30 p.m. BPA First Timer's Luncheon

1:30- 2:00 p.m. Combined Opening Ceremonies

2:00- 3:00 p.m. Combined Scientific Session: THE SLIDE AND FILMSTRIP
The roles of the speaker, illustrator and photographer in the preparation of effective projectuals will be presented. Special emphasis will be placed on combined techniques of art and photography.
Television Workshop

3:00- 3:45 p.m. Intermission: To view Exhibits & Coffee Break
Mini Workshops
Speaker Feed-Back Sessions

3:45- 5:00 p.m. Combined Scientific Session: THE PUBLISHED IMAGE
Preparation of art and photography for scientific publication will be discussed. The coordination of efforts of the author, biocommunicators and publisher will be emphasized.

5:00 p.m. Concurrent Specialized Sessions

7:00 p.m. BPA Get Acquainted Party, AMI Dinner

TUESDAY, 11 AUGUST 1970

9:00-10:15 a.m. BPA & AMI Scientific Sessions, Television Workshop
Film and Videotape Viewing

10:15-10:45 a.m. Intermission: To view Exhibits & Coffee Break

10:45-12:00 noon BPA & AMI Scientific Sessions

12:00- 1:30 p.m. BPA Official Luncheon, AMI Presidential Luncheon

1:30- 3:00 p.m. Combined Scientific Session: MEDICAL TELEVISION
Techniques involved in the production of effective television presentations will be discussed and examples shown. Emphasis will be on a multidisciplinary approach to this important teaching medium.

3:00- 3:45 p.m. Intermission: To view Exhibits & Coffee Break
Mini Workshops, Speaker Feed-Back Sessions

3:45- 5:00 p.m. Combined Scientific Session: MEDICAL TELEVISION

5:00 p.m. Concurrent Specialized Sessions

7:00 p.m. Combined BPA-AMI-CMT Board Meeting and Dinner

8:00 p.m. CMT Television Workshop
Film & Videotape Viewing

WEDNESDAY, 12 AUGUST 1970

9:00-10:15 a.m. BPA & AMI Business Meetings
CMT Television Workshop
Film & Videotape Viewing for Other Participants

10:15-10:45 a.m. Intermission: To view Exhibits & Coffee Break

10:45-12:00 noon BPA & AMI Scientific Sessions

12:00- 1:30 p.m. Lunch

1:30- 3:30 p.m. Combined Scientific Session: THE TEACHING FILM

The various steps in the production of a teaching film will be presented. Emphasis will be placed on the specific techniques of art and photography appropriate to this medium.

3:30- 4:00 p.m. Intermission: To view Exhibits & Coffee Break

4:00- 5:30 p.m. Concurrent Specialized Sessions

6:30 p.m. Cocktail Hour

7:30 p.m. Combined Awards Banquet

THURSDAY, 13 AUGUST 1970

9:00 a.m. Concurrent Specialized Sessions ADMINISTRATION OF THE BIOCOMMUNICATIONS DEPARTMENT
INFORMATION STORAGE AND RETRIEVAL
EDUCATION OF THE BIOCOMMUNICATOR
WRITING FOR PUBLICATION

10:15-10:45 a.m. Intermission: To view Exhibits & Coffee Break

10:45-12:00 noon Concurrent Specialized Sessions

12:00- 1:30 p.m. Lunch

1:30- 3:00 p.m. Combined Scientific Session: THE SCIENTIFIC EXHIBIT

Various approaches to the design and production of a scientific exhibit will be presented. Emphasis will be placed on guidelines for an effective presentation.

3:30 p.m. BPA-Final Business Meeting

Official Announcement of the Board of Registry . . .

THE Board of Registry, Biological Photographic Association, Inc., announces that each of the below-listed persons having duly satisfied all requirements has been issued appropriate numbered certification as a Registered Biological Photographer in the specialty field indicated, is entitled to so proclaim by use of the letters R.B.P. following his name, and that together they comprise The Registry as of September 1, 1969.

Applications to take the three-phase senior level examination leading to certification are now available. Any person with five years of full-time or equivalent part-time experience as a biological photographer is eligible to apply. Procedural details and application forms may be obtained from the Secretary, Will E. Renner, RBP, Medical Illustration, School of Medicine, University of California, Davis, Calif. 95616, U.S.A.

Registrant	*Location*	*Reg. No.*	*Field of Specialty*
ALBRIGHT, Robert F., FBPA	Indianapolis, Ind.	13	Medicine
ANDERSON, Douglas C., FBPA	Sault Ste. Marie, Ont., Can.	8	Nat. Sci.
ATKINSON, William H.	Miami, Fla.	110	Medicine
BAILEY, Charles M.	Miami, Fla.	111	Medicine
BAITZ, Harold C., FBPA	Buffalo, N.Y.	9	Medicine
BALDWIN, E. Lynn, FBPA	Houston, Tex.	62	Medicine
BENJAMIN, Alfred	Los Angeles, Calif.	14	Medicine
BLAKER, Alfred A.	Berkeley, Calif.	112	Nat. Sci.
BLICKENSTAFF, John E.	Chicago, Ill.	113	Dentistry
BOLLETER, M. Wayne	Dallas, Tex.	44	Medicine
BOWDEN, Arthur J.	Detroit, Mich.	63	Medicine
BOWERMAN, Leland M.	Morgantown, W. Va.	64	Medicine
BOWMAN, Raymond C.	Farmingdale, N.Y.	114	Nat. Sci.
BROOK, Gerald Allenby	Dunedin, New Zealand	115	Medicine
BROOKS, Percy W., FBPA	New York, N.Y.	51	Medicine
BROWN, Laurence B., FBPA	Boston, Mass.	65	Dentistry
BROWN, Robert A.	Charleston, S. C.	66	Medicine
BROWNELL, Charles, FBPA	Rochester, N. Y.	116	Medicine
BRUNINGS, Martha M.	Rochester, N.Y.	117	Medicine
BUCKLEY, Kenneth	Vancouver, B. C.	12	Medicine
BURCH, J. Lindsey	Baltimore, Md.	67	Medicine
CARTER, Richard F.	New York, N.Y.	190	Medicine
CHENEY, Maynard C.	Framingham, Mass.	118	Medicine
CHRISTENSON, LeRoy P.	St. Paul, Minn.	69	Medicine
CHRISTOPHER, Ronald M., FBPA	Philadelphia, Penna.	70	Medicine
CLARK, Richard L.	Cincinnati, Ohio	71	Medicine
COFFEY, Lardner A., FBPA	Rochester, Minn.	2	Medicine
CRAWFORD, J. Richard	Philippi, W. Va.	15	Medicine
DANT, J. Robert	Augusta, Ga.	171	Medicine
DAVID, Robert E.	Philadelphia, Penna.	72	Medicine

Registrant	Location	Reg. No.	Field of Specialty
DAVIS, Gene K.	Houston, Tex.	73	Medicine
DAVIS, S. Jack	Iowa City, Iowa	119	Medicine
deBLOIS, John Despard	Ottawa, Ont., Canada	120	Nat. Sci.
de BRUIN, Jack P.	Chicago, Ill.	74	Medicine
DEUTSCH, Charles J.	Ames, Iowa	75	Medicine
deVEER, William H.	Rochester, N.Y.	193	Medicine
DILLARD, Albert E.	Los Angeles, Calif.	76	Medicine
DITTMAN, Stephen P., Jr., FBPA	Charleston, S. C.	77	Medicine
DODGE, Timothy P.	Anaheim, Calif.	121	Medicine
DOMMASCH, Hans S., FBPA	Saskatoon, Sask., Canada	41	Medicine
DUNTON, Samuel C., FBPA	Bronx, N.Y.	78	Nat. Sci.
EASTMAN, Wynne S.	New York, N.Y.	122	Medicine
EDWARDS, Otis Thomas	Chapel Hill, N. C.	200	Medicine
EHLIN, Marvin	Brooklyn, N.Y.	79	Medicine
EHRLICH, Sam G.	San Francisco, Calif.	80	Medicine
ENGEL, Charles E., FBPA, FRPS, FIBP	London, England	31	Medicine
FACTO, Louis A., FBPA	Ames, Iowa	16	Vet. Med.
FASON, Jack, FBPA	Denver, Col.	123	Medicine
FISCHLER, Herbert A.	Brooklyn, N.Y.	17	Medicine
FORD, John E.	Dayton, Ohio	124	Medicine
FREEHE, Clifford L., FBPA	Seattle, Wash.	3	Dentistry
FRIEDMAN, Harold	Brooklyn, N.Y.	81	Medicine
FRITTS, Donald Harry, FBPA	Bozeman, Mont.	10	Vet. Med.
GARNEAU, Jean	Montreal, Que., Canada	201	Nat. Sci.
GAUGHAN, John A.	Columbia, Mo.	125	Medicine
GAUTHIER, John M.	Montreal, Que., Canada	82	Medicine
GEORGE, Terry W.	Baltimore, Md.	164	Medicine
GIBSON, Daniel A.	Winnipeg, Man., Canada	83	Medicine
GIBSON, H. Lou, FBPA, FPSA, FRAS, FRMS	Rochester, N.Y.	4	Medicine
GIGUERE, Marc	Charlesbourg, Que., Canada	126	Medicine
GILLIAM, Cecil D.	Phoenix, Ariz.	18	Medicine
GILLIAM, Luther R.	Perry Point, Md.	127	Medicine
GJERSVIK, Torleif	Memphis, Tenn.	50	Medicine
GLASER, Jane K.	Argonne, Ill.	39	Nat. Sci.
GLAZIER, Ralph M.	Ames, Iowa	48	Medicine
GLORE, James F.	Indianapolis, Ind.	172	Medicine
GONZALEZ, Fernando G., FBPA	Miami, Fla.	19	Medicine
GOODMAN, Leo	Boston, Mass.	128	Medicine
GRAVER, Nicholas Maurer	Rochester, N.Y.	165	Medicine
GRAVESEN, Alex A., FBPA	Memphis, Tenn.	20	Medicine
GREENBERG, Wilfred	Brooklyn, N.Y.	129	Medicine
HANSELL, Dr. Peter, FBPA, FRPS, FIBP	London, England	11	Medicine
HART, Leonard M.	Durham, N. C.	130	Medicine
HEITLINGER, Lester	Pittsburgh, Penna.	131	Medicine
HELMER, Norman C.	Vancouver, B.C., Canada	173	Medicine
HENNING, Rudolph J.	Bronx, N.Y.	133	Medicine
HERSKOVITZ, Antol H.	Bronx, N.Y.	132	Medicine
HILBRAND, David	Oklahoma City, Okla.	84	Medicine
HODGE, Charles P., FBPA	Montreal, Que., Canada	32	Medicine
HOOTNICK, Dr. Harry L.	Chicago, Ill.	134	Medicine
IKENBERG, Maria, FBPA	Chicago, Ill.	33	Medicine
JACKSON, Harold Ross, FBPA	Ottawa, Ont., Canada	85	Nat. Sci.
JACOBSON, Marjorie E.	Buffalo, N.Y.	86	Medicine

Registrant	Location	Reg. No.	Field of Specialty
JERRY, Norman L.	London, Ont., Canada	136	Nat. Sci.
JOHNSON, Paris C.	Indianapolis, Ind.	135	Medicine
JULIN, Leonard A., FBPA	Rochester, Minn.	5	Medicine
JUNOR, John Matheson	Saskatoon, Sask., Canada	166	Medicine
KANTOR, Nathan C.	New York, N.Y.	174	Medicine
KERR, Carol Elizabeth	San Francisco, Calif.	21	Medicine
KINDELL, William A.	Wauwatosa, Wisc.	137	Medicine
KLOSEVYCH, Stanley, FBPA, FRMS	Ottawa, Ont., Canada	22	Medicine
KOSTER, Lewis W., FBPA	Pearl River, N.Y.	34	Medicine
KUZMA, Anthony M., FBPA	Milwaukee, Wisc.	87	Medicine
LANDI, Victor R.	Washington, D. C.	88	Medicine
LANNON, Thomas J., FBPA	Cleveland, Ohio	138	Medicine
LAPPAN, Joseph Thomas, FBPA	Arlington, Va.	139	Medicine
LaRUE, Mervin W., Sr., FBPA	Chicago, Ill.	109	Medicine
LEAPLEY, McKinley	Indianapolis, Ind.	68	Medicine
LE COVER, Maurice, FBPA	Los Angeles, Calif.	89	Medicine
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